

**Coral Reef Monitoring and Biodiversity Assessment to support  
the planning of a proposed MPA at Andavadoaka.**



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## EXECUTIVE SUMMARY

- A comprehensive coral reef monitoring and biodiversity assessment was conducted at Andavadoaka, southwest Madagascar during November and December 2005.
- Coral reef monitoring was completed for benthic cover, reef fish biomass and macro-invertebrates at nine permanent sites across three main reef types with preliminary information collected at a tenth site (a deep offshore patch reef). Monitoring data provided further detail of coral reef status, complementing and enhancing the existing monitoring completed in the Andavadoaka region.
- An assessment of marine biodiversity in the Andavadoaka region was made by international taxonomic experts for hard corals, reef fish and marine molluscs at a range of habitats and reef types.
- The condition of coral reefs in the region varied between the main reef types. Nearshore fringing reefs were generally in poor condition with low hard coral cover, high non-calcified algal cover and low reef fish biomass. Seaward facing barrier reefs are in better condition with slightly higher coral cover and reef fish biomass. Patch reefs below 10 metres depth were in the best condition with high coral cover, high structural complexity and greatest reef fish biomass. Extensive coral bleaching events are thought to be responsible for low hard coral cover on shallow reefs (<10 m depth).
- Total reef fish biomass (14 main families) was similar to levels found for moderately fished reefs in East Africa and Beheloka, southwest Madagascar. Biomass for some herbivorous fish families was low on fringing reefs (Acanthurids) whilst Scarid biomass was reduced across all sites surveyed.
- Macro-invertebrate density varied between the main reef types with higher densities of herbivorous urchins and seastars (*Linckia* spp.) on fringing reefs and higher densities of giant clams, holothurians and large Cypraeids on offshore reefs.
- Biodiversity assessments revealed medium biodiversity levels for hard corals and reef fish and high biodiversity for marine molluscs. Some hard coral genera were recorded less often than expected which is likely to be related to bleaching mortality. Specialist reef fish associated with rich coral areas were also absent.
- Biodiversity assessments also showed that in order to adequately conserve the maximum number of species it is necessary to protect the full range of coral reef habitats across the different reef types present in the region. In particular the patch reef complex and the southern end of Nosy Hao reef are recommended for full protection.
- A number of recommendations for management are proposed including the use of multiple zones for marine protected and resource-use areas, restrictions on destructive fishing practices, full investigation of a range of alternative livelihoods for fishers and building capacity for community based management within local villages.
- It is crucial that management of any designated marine protected areas in the region is made with the full co-operation and continuous support of the local communities.

## INTRODUCTION

This study was conducted specifically for two main reasons; firstly to undertake a detailed assessment of the marine biodiversity within the Andavadoaka region and secondly to complement and enhance the previous ecological monitoring completed on coral reefs at Andavadoaka. The dataset collected aims to record the current status of the marine ecosystem and will provide crucial information to enable the demonstration of effectiveness of the proposed marine protected area (MPA) over time. The work undertaken directly contributes to Objective 4 of the Plan of Action (Cadre Logique) for the 'Andavadoaka Project' originally devised for funding secured from the French Government's 'Fonds de Solidarité Prioritaire' (FSP) for the period January 2005 – June 2006.

The 'Andavadoaka Project's overall aim is to demonstrate the effectiveness of marine protected areas for the conservation of the coastal environment and the sustainable management of marine resources. It is a multi-partner project involving national and local government, international conservation NGO's, the national marine institute for Madagascar (I.H.S.M.), a commercial fish collection company and local communities in the Andavadoaka region. The project has a range of objectives which include baseline ecological and socio-economic assessments; ongoing ecological, fisheries, and socio-economic monitoring; investigation and demonstration of fisheries management practices and the setting up of alternative sources of income for fishing communities.

Ecological monitoring and baseline studies of the marine and coastal environment at Andavadoaka has been completed over the last two years by Blue Ventures, a UK not-for-profit NGO, which has been based on site since 2003. Data collected between September 2004 and July 2005 is presented in Nadon et al. (2005). The majority of the manpower used for data collection are volunteers with no or little previous marine biological background. The level of detail that can be recorded by volunteers on marine surveys is limited. However studies confirm that, given the proper training and supervision, data collected by volunteers can be relied upon to assess the diversity and status of coral reefs at a low to medium level of taxonomic complexity for fish, hard corals and selected macro-invertebrates (Mumby et al., 1995; Harding et al., 2000). The accuracy of the data collected is maintained by rigorous training and testing of volunteers before they are permitted to take part in assessments. A standardized coral reef monitoring programme has been in place since September 2004 using a combination of trained, non-specialist volunteers and marine biologists.

To increase the level of detail a second programme of marine assessment and monitoring was proposed. This will enable the status of the marine environment and the subsequent effectiveness of marine protection to be revealed in more detail. Collaboration with international taxonomic experts enabled the production of a thorough species inventory for selected taxa of marine fauna, notably hard corals, reef fish and marine molluscs. The presence and status of nationally or globally threatened and regionally endemic species was also recorded. These species can then be incorporated as targets in subsequent monitoring programs.

The results of this monitoring and assessment program also contribute to the 'Durban Vision' of substantially increasing the total amount of protected areas on a national scale

by 2008, as initially announced by the President of Madagascar at the World Parks Congress in 2003 and reiterated in June 2006 at the Biodiversity Symposium organised by Conservation International in Antananarivo.

## Objectives

The main objectives of this study were to:

1. Conduct a rapid assessment of biodiversity in the Andavadoaka region involving international experts;
2. Initiate a more detailed level of biological monitoring at range of reef habitats using a combination of experienced surveyors from WCS, Blue Ventures, IRD / ARVAM and I.H.S.M (depending on availability)
3. Use the information collected to make recommendations for the designation of the proposed MPA and the management of marine resources in the region.

## METHODS

### Marine Biodiversity

Biodiversity assessments were conducted by taxonomic experts for reef fish, hard corals and molluscs incorporating both in-situ observation (reef fish, hard corals) and sample collection (hard corals, molluscs) to record fauna to the species level. Sampling sites were chosen to represent all known habitat types in shallow coastal waters around Andavadoaka to a depth of 30 metres. Full details of the methods used for the biodiversity assessments can be found in the individual reports for reef fish (Allen, 2005), hard corals (Fenner, 2005) and molluscs (Barrere, 2005) which are included in this report as Appendices I - III.

### Ecological Monitoring

The monitoring completed during this assessment was designed to complement the existing ecological data set collected by Blue Ventures by recording faunal groups in more detail. The advanced monitoring undertaken is summarized below (Table 1) which also provides information on the routine monitoring completed by Blue Ventures throughout the year.

**Table 1. Summary of Ecological Monitoring at Andavadoaka**

Level of Ecological Monitoring	Organisation responsible	Monitoring Type	Sampling Period
Basic	BV	Benthic cover and hard coral recruits	Bi-annually
Basic	BV	Reef fish abundance (selected families)	Bi-annually
Basic	BV	Target invertebrates	Bi-annually
Advanced	WCS	Reef fish biomass: belt transects	Annually
Advanced	WCS	Reef fish biomass: timed swims	Annually
Advanced	WCS / BV	Target invertebrates: belt transects	Annually
Advanced	WCS / BV	Target invertebrates: timed swims	Annually
Advanced	WCS	Benthic cover: Identification to genus	Annually

The above table shows the types of advanced monitoring originally proposed for completion at Andavadoaka. However, a lack of trained personnel for most survey dives meant that it was not possible to complete 'timed swim' surveys for invertebrates and reef fish. Ecological monitoring of coral reefs and associated systems followed standard methodology as used by the Global Coral Reef Monitoring Network (GCRMN) and outlined in Hill and Wilkinson (2004).

## Study Sites

The more advanced monitoring was completed at a number of existing sites used for routine monitoring by Blue Ventures in order to provide further ecological detail for these locations covering a range of reef types (patch, barrier and fringing) which are also positioned both within and outside of the proposed MPA for Andavadoaka. Details of the study sites and their relative locations are provided in Table 2 and Figure 1 respectively. Three sites for each main reef type were assessed plus one site at a fourth reef habitat, the deeper offshore patch reef at Andravamaike. Site names followed those given by Blue Ventures surveyors with the exception of the offshore patch site, which uses the local name.

**Table 2. Details of Ecological Monitoring Sites.**

Site Name	General Location	Reef Type	Latitude (South)	Longitude (East)	Depth (m)
007 (S)	East of the	Patch	22° 07' 25.30"	43° 11' 49.10"	8-10
Recruitment (N)	southern end of	Patch	22° 07' 20.30"	43° 11' 53.60"	11-13
THB (S)	Nosy Hao Reef	Patch	22° 07' 25.40"	43° 11' 54.40"	10-12
Valleys	NW Nosy Hao reef	Barrier	22° 04' 46.50"	43° 10' 55.80"	6-10
Shark Alley	Southern end of Nosy Hao reef	Barrier	22° 07' 47.60"	43° 10' 52.70"	8-12
Nosy Fasy	SW side of Nosy Fasy reef	Barrier	22° 04' 01.10"	43° 10' 54.00"	8-12
Coco Beach	SW of Coco Beach Resort	Fringing	22°05' 03.80"	43° 13' 39.40"	5-9
Half Moon	West of Coco Beach Resort	Fringing	22°04' 27.00"	43° 13' 34.90"	6-10
Andavadoaka Rock	Adjacent to Andavadoaka Rock	Fringing	22°04' 22.00"	43° 13' 34.30"	5-8
Andravamaike	3 km west of Nosy Hao	Offshore Patch	22° 04' 32.2"	43° 09' 15.50"	20-22

## **Survey Methods**

### **Environmental Parameters**

On each survey dive a number of environmental parameters were recorded on the boat either just before or immediately after the survey. These included sea surface temperature (SST°C), sea state (Beaufort Scale; 1-12), wind direction and cloud cover (0-8).

### **Benthic Cover**

Benthic cover was recorded using the point intercept transect method (PIT) on permanent transects established by Blue Ventures (except at Andravamaïke). For all but three of the survey sites 8 replicate transects each 10 metres in length were completed by laying a tape measure along the transect between fixed points (permanent metal stakes). For the remaining sites 6 transects were completed at two of the patch reef sites (Recruitment and 007) while 4 transects were surveyed at the deep offshore patch reef, Andravamaïke. The type of cover (biotic or abiotic) present under each 20 cm increment along the tape was recorded using the standard categories recommended by GCRMN (Hill and Wilkinson, 2004) and listed in Appendix 4c. Sessile organisms were recorded to genus 'in situ' when possible. Digital cameras were used to record organisms not fully identified during the survey for subsequent identification at the field base using the following guides and texts: Veron (2000) for hard corals; Fabricus and Alderslade (2004) for soft corals; Littler and Littler (2003) for marine algae and Richmond (2002) as a general guide.

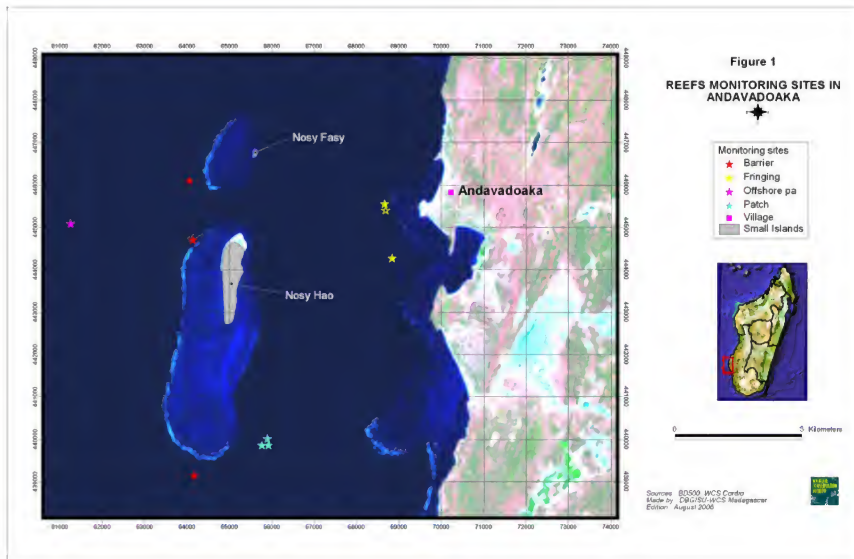
### **Reef Fish**

Underwater visual censuses were conducted to estimate the biomass of sixteen fish families (Appendix 4a) representing the main trophic groups of reef fish occurring in the Andavadoaka region and most of the main fish families targeted by local fishers. At each site the selected families were counted along three replicate belt transects 50 metres in length, 5 metres wide and 5 metres deep giving a total area of 250 m<sup>2</sup>. Individual fish in each selected family were recorded and allocated either to 5 cm size classes between 0 and 50 cm total length (TL) or to 10 cm size classes between 50 and 100 cm TL. Pomacentrids were split into two trophic groups, herbivores and planktivores according to their feeding habit. Reef fish biomass for each family was calculated using biometric equations derived from reef fish populations sampled in Kenya (McClanahan et al., 1996) and converted to kg per hectare (kg/ha) of reef area.

### **Macro Invertebrates**

Selected macro-invertebrates were also recorded along each of the 50 x 5 metre belt transects (Appendix 4b). Individual organisms were identified to species when possible. Commercially harvested (sea cucumbers, octopus), rare (large Gastropod molluscs) or ecologically significant (herbivorous urchins) invertebrates were those selected for monitoring.





## RESULTS

The majority of information presented derives from the data collected during monitoring surveys completed between the 26<sup>th</sup> of November and the 6<sup>th</sup> of December 2006. For some comparisons biodiversity data derived from Appendices I - III and collected in the same time period are also presented.

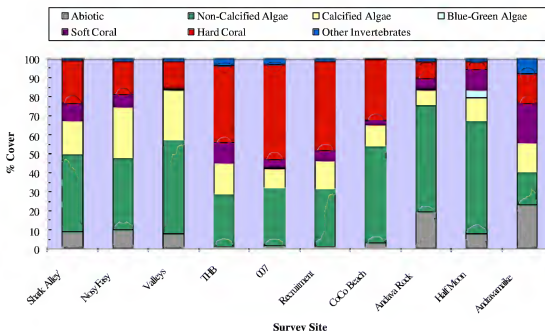
### Environmental Parameters

A complete set of environmental data collected can be found in Appendix 5. Sea surface temperature remained between 28 and 29 °C during the monitoring. Sea state ranged between 2 and 4 on the Beaufort Scale and usually increased throughout the day. Cloud cover was generally low when surveys took place and never exceeded 4 octets. The wind was predominantly from the southwest with occasional days where it came from the north or northwest.

### Benthic Composition

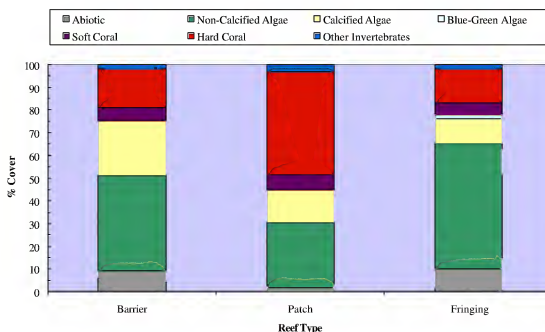
Mean values of percent cover for all benthic categories recorded at each site are presented in Appendix 6. Values for the major categories are highlighted in bold and presented graphically in Figure 2 for individual sites and Figure 3 for the three main reef types (not including Andravamaike). Hard coral cover was significantly higher at the patch reef sites (THB, 007 and Recruitment), between 40 and 50 %, than at the barrier reef or nearshore fringing reef sites (Table 4). At one nearshore site (Coco Beach) hard coral cover was moderately high (32 %) and can be attributed to a large submassive colony of *Pavona clavus*, which constituted 27.5 % of all benthic cover at this site (Table 3). Hard coral cover at the other fringing reef sites was less than 10 % and very low at Half Moon (4 %).

Figure 2. Mean benthic cover at 10 coral reef sites at Andavadoaka.



Algae covered more than half of the substratum at six of the ten sites visited, reaching 75 % cover at two of these sites, Valleys and Half Moon. Looking at algal cover in more detail barrier reef sites have a significantly higher proportion of calcified algae than either patch or fringing reef sites (Table 3). For the latter reef type, non-calcified algae (turf and macroalgae) consistently made up between 50 – 60 % of the total benthic cover (Figures 3-4, Appendix 6). Blue-green algae were recorded at three sites and were most prominent at the nearshore site Half Moon (4.25 %). Total non-calcified algal cover was significantly greater on fringing or barrier reefs than on patch reefs but also significantly higher on fringing compared to barrier reefs (Table 3).

**Figure 3. Mean Benthic Cover by Reef Type for three main types of coral reef at Andavadoaka.**



Soft corals and other benthic invertebrates (sponges, zooanthids, anemones and bivalve molluscs) generally covered less than 10 % of the substratum for the main reef types. The exceptions were THB (14 %) and Half Moon (12.25 %). The deeper patch reef at Andravamaike consisted of a different coral reef habitat with greater soft coral and sponge cover than any other site (Figure 2, Appendix 6). Algal cover was also lowest at Andravamaike (33 %) and abiotic substratum highest (23 %), the latter mainly consisted of sand patches between areas of reef.

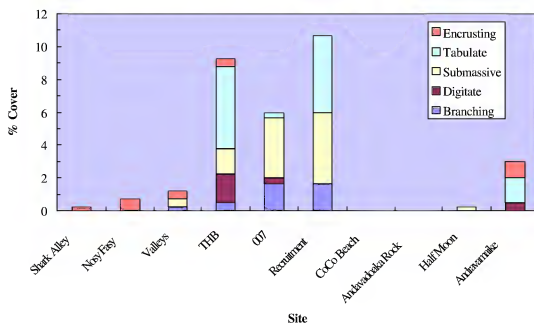
**Table 3 Comparison of selected benthic categories between reef types.**

Benthic Category	F	P	Comparison Between Reef Type		
			Barrier x Patch	Barrier x Fringing	Patch x Fringing
Total Hard Coral	33.01	<0.0001	P > B	n.s	P > F
Non- <i>Acropora</i> Corals	14.94	<0.0001	P > B	n.s	P > F
<i>Acropora</i> Corals	60.88	<0.0001	P > B	B > F	P > F
Calcified Algae	15.94	<0.0001	B > P	B > F	n.s
Non-Calcified Algae	16.29	<0.0001	B > P	F > B	F > P

Oneway ANOVA on arcsin transformed data. (df = 2, 65; F critical = 3.138) with a Tukey test to identify significant differences ( $p < 0.05$ ) between groups (n.s. = not significant).

Hard coral types (*Acropora* or Non-*Acropora*) and lifeforms varied considerably between survey sites and reef types (Appendix 6, Figures 4–5). *Acropora* corals were rarely recorded at the barrier and fringing reef sites (<2 % cover) and not recorded at all on transects at two of the nearshore sites. *Acropora* coral cover was significantly higher at patch reef sites than at barrier or fringing reef sites (Table 3). However, cover by this genus was generally less than 10 % and consistently less than 25% of all hard coral cover. Tabulate and digitate forms of *Acropora* were only recorded at patch reef sites.

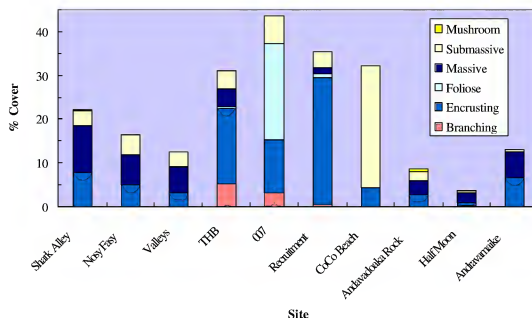
**Figure 4. Proportion of *Acropora* Lifeforms at Andavadoaka coral reef sites**



In contrast, non-*Acropora* corals covered between 12 and 44 % of the substratum at eight of the sites surveyed (Appendix 6, Figure 5). The two exceptions were both fringing reef sites, Andavadoaka Rock and Half Moon where cover was less than 10 %.

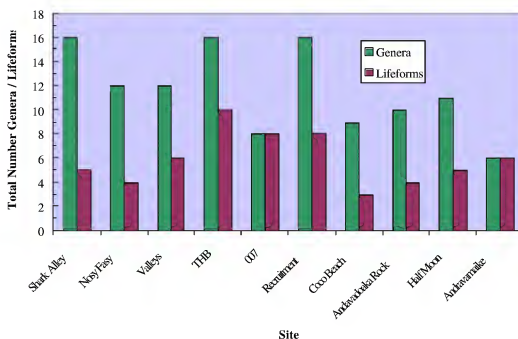
Cover of non-*Acropora* corals was significantly higher at patch reef sites than at the other two reef types (Table 3). Patch reefs were also the only sites where branching and foliose lifeforms were recorded with foliose *Montipora* colonies covering more than 20% of the reef area at one site ('007').

**Figure 5. Proportion of Non-Acropora Lifeforms at Andavadoaka coral reef sites**

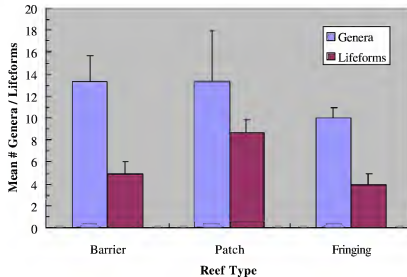


A total of 28 hard coral genera were recorded during monitoring surveys (Appendix 7). On average 93.4 % of hard coral colonies recorded along the transects were identified to genus (all sites combined). The highest number of hard coral genera was recorded at three sites; Shark Alley, 'THB' and Recruitment. More hard coral genera were recorded on transects at patch and barrier reef sites than at fringing reef sites. Patch reef sites also contained a larger range of hard coral lifeforms than the other two reef types (Figure 7).

**Figure 6 Total Number of Hard Coral Genera and Lifeforms recorded at 10 sites during monitoring surveys.**

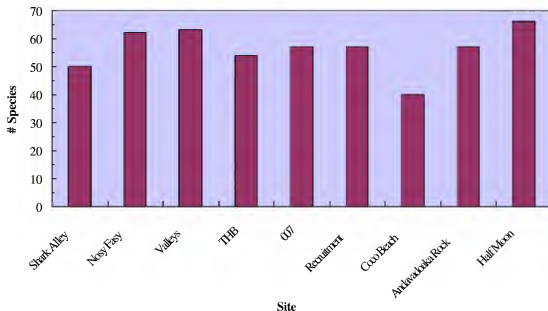


**Figure 7** Number of hard coral genera and lifeforms for each main reef type at Andavadoaka (mean values + S.D., n = 3).

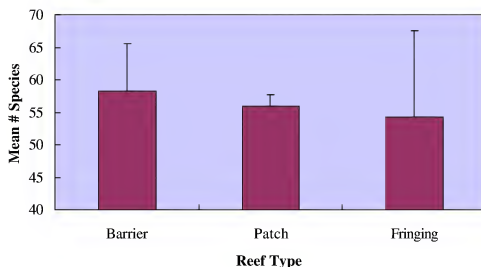


In terms of hard coral species the assessment by Fenner during the monitoring trip (see report in Appendix 1) showed the total number recorded on one dive can vary considerably between sites of the same reef type (Figure 8). Fringing reef sites produced the highest and lowest counts of hard coral species, 66 and 40 respectively for one 60 minute dive. When sites are combined into the three main reef types (Figure 9) the mean number of species is slightly higher at barrier and patch reef sites than at the nearshore sites but not significantly so (Oneway ANOVA,  $p = 0.857$ ).

**Figure 8** Maximum number of hard coral species recorded on one 60 minute dive at nine sites at Andavadoaka (Fenner, 2005).



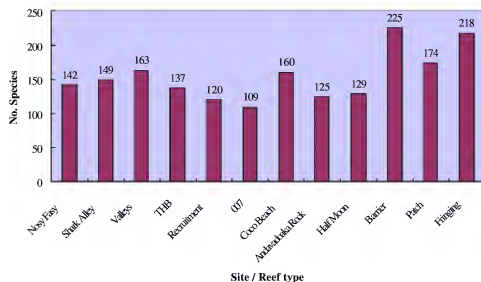
**Figure 9** Number of hard coral species for each main reef type at Andavadoaka (mean values + S.D., n = 3).



## Reef Fish

Reef fish diversity was assessed by G. Allen at the nine sites visited for monitoring surveys (Allen, 2005: Appendix 2). Comparison of reef fish diversity between sites and reef types is depicted below (Figure 10). The total number of species recorded at each site varied between 109 ('007') and 163 (Valleys). Coco Beach was the only other site to have more than 150 species. Analysis by reef type indicates that the highest number of species was found at the barrier reef sites, closely followed by fringing reefs (Figure 10). Patch reef sites were considerably less diverse with a total of 174 species compared to counts in the early 200's for the other reef types.

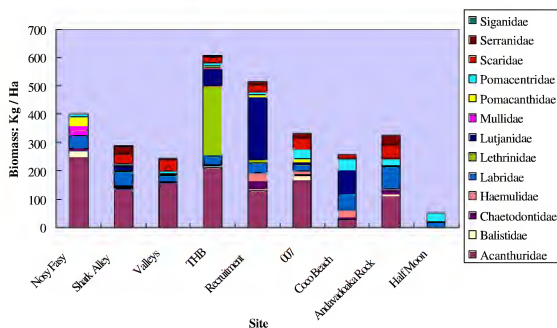
**Figure 10** Total number of reef fish species recorded over 2 dives for nine sites with accumulated values for reef types at Andavadoaka (Allen, 2005).



Reef fish biomass was also assessed at nine sites covering the three main reef types. Mean values for the main fish families recorded at each site are presented in Figure 11 and Appendix 8a, with standard errors provided in Appendix 8b. Values for Caesionids are omitted from Figure 11 but present in Appendix 8. Reef fish biomass was highest at two of the patch reef sites, THB and Recruitment with 514 and 607 kg/ha respectively, not including Caesionids. Lowest values for biomass were recorded at the fringing reef site Half Moon with a total of 52.5 kg/ha. The high values at the two patch reef sites were caused by the presence of schools of Lethrinids and Lutjanids which were absent from almost all other reef sites, with the exception of Coco Beach (Lutjanids). Acanthurids made up a significant part of the total reef fish biomass for most sites, particularly at the barrier reef sites where they represented between 37 and 62 % of total biomass for the families recorded.

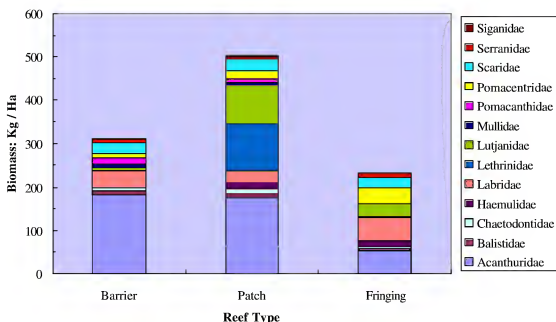
Comparison of fish biomass by main reef type indicates that the patch reefs harbour the greatest mass of reef fish, and the highest biomass of Lethrinids, Lutjanids, Chaetodontids and Scarids compared to barrier and fringing reefs (Figure 12). There was a significant difference in total reef fish biomass (excluding Caesionids) between reef types (Oneway ANOVA on log(x) transformed data:  $df = 2, 21$ ;  $p = 0.032$ ) with fringing reefs recording significantly less total biomass than patch reefs (Tukey test;  $p < 0.05$ ).

**Figure 11** Mean reef fish biomass for 13 fish families at nine sites at Andavadoaka





**Figure 12 Mean reef fish biomass for 13 fish families at the main reef types**

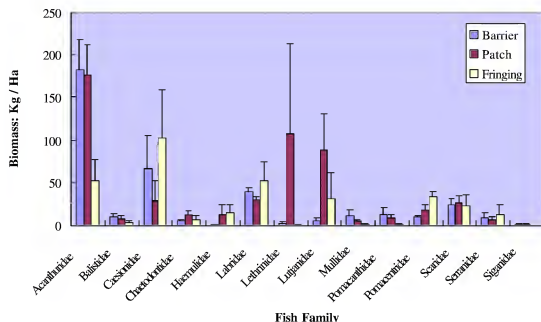


Three families significantly differed in biomass between reef types (Table 4). Biomass of Acanthurids was lower on fringing reefs than barrier or patch reefs while a higher biomass of Lutjanids was recorded on patch reefs than on the other reef types. Conversely biomass of Pomacentrids was significantly higher on fringing reefs than patch or barrier reefs. Labrids were also most abundant on fringing reefs but not significantly so (Table 4). Lethrinid biomass was significantly higher on patch reefs if accepted at a slightly lower level of probability ( $p = 0.07$ ).

The variance in fish biomass between replicate counts for some families is highlighted in Figure 13 and partly accounts for the lack of statistical difference between reef types (Table 4). Standard errors are particularly high for Caesionids for all reef types and both Lutjanids and Lethrinids at patch reefs. Other families such as Scarids and Labrids provided relatively consistent results between transects and also between reef types.

Seven fish families did not exceed a mean biomass of 15 kg/ha at any reef type (Appendix 8a, Figure 13). These were mainly carnivores (Balistids, Serranids, Haemulids, Mullids) but also included mixed feeders (Chaetodontids, Pomacanthids) and one herbivorous family (Siganids).

**Figure 13** Reef fish biomass for 14 families at three main reef types  
(Mean values + S.E.).



**Table 4** Comparison of Reef Fish Biomass between Reef Types for 12 Families.  
(Significant differences are highlighted in bold)

Oneway ANOVA on  $\log(x+1)$  transformed data. (df = 2, 21; F critical = 3.47) with a Tukey test to identify significant differences ( $p < 0.05$ ) between groups (n.s. = not significant, \* = significant at  $p < 0.07$ ).

Fish Family	F	P	Comparison Between Reef Type		
			Barrier x Patch	Barrier x Fringing	Patch x Fringing
<b>Acanthuridae</b>	<b>9.05</b>	<b>&lt; 0.005</b>	n.s.	<b>B &gt; F</b>	<b>P &gt; F</b>
Balistidae	1.55	0.236	-	-	-
Caesionidae	0.30	0.745	-	-	-
Chaetodontidae	1.08	0.359	-	-	-
Labridae	0.42	0.660	-	-	-
<b>Lethrinidae</b>	<b>3.47</b>	<b>0.05*</b>	n.s.	n.s.	<b>P &gt; F*</b>
<b>Lutjanidae</b>	<b>7.69</b>	<b>0.003</b>	<b>P &gt; B</b>	n.s.	<b>P &gt; F</b>
Mullidae	2.29	0.126	-	-	-
Pomacanthidae	1.78	0.193	-	-	-
<b>Pomacentridae</b>	<b>13.45</b>	<b>&lt; 0.001</b>	n.s.	<b>F &gt; B</b>	<b>F &gt; P</b>
Scaridae	1.10	0.350	-	-	-
Serranidae	0.16	0.856	-	-	-

## Macro-Invertebrates

Mean counts for assessed macro-invertebrates at each site are presented in Appendix 9 while overall means with standard errors for each reef type are depicted below (Table 4). A few macro-invertebrate targets were more notable by their absence, particularly Crown of Thorns starfish (*Acanthaster planci*) and Lobsters (*Panulirus* spp.), which were not recorded along transects at any site. One octopus was observed during the surveys, at Nosy Fasy. A high density of large anemones (*Heteractis* sp.) was recorded at one patch reef site ('THB') but were either absent or rarely recorded at other sites.

In terms of Echinoderms herbivorous sea urchins (*Diadema*, *Echinometra* and *Echinothrix*), the sea star *Linckia* spp. and the sea cucumber *Pearsonothuria graeffei* were recorded most often. Four genera of sea-stars (*Culcita*, *Choriaster*, *Protoreaster* and *Nardoa*) were recorded occasionally (Appendix 8).

Large gastropod molluscs such as the giant triton (*Charonia tritonis*) and horned helmet shell (*Cassia cornuta*) were not seen at any of the nine sites. However, medium sized gastropods were observed. The conch (*Lambis* spp.) and two species of large cowrie, the Tiger (*Cypraea tigris*) and Egg Cowrie (*Ovula ovum*), were recorded. The latter was frequently observed on barrier reef sites at Nosy Fasy and Valleys.

**Table 4** Densities of selected macro-invertebrates for three reef types at Andavadoaka (no. individuals / hectare).

Invertebrate Category	Barrier		Patch		Fringing	
N:	9		7		8	
	Mean	S.E.	Mean	S.E.	Mean	S.E.
<i>Diadema</i>	<b>31.11</b>	<b>22.11</b>	<b>531.43</b>	<b>309.22</b>	<b>290.00</b>	<b>215.60</b>
<i>Echinothrix</i>	0	-	142.86	75.93	<b>640.00</b>	<b>291.48</b>
<i>Echinometra</i>	<b>302.22</b>	<b>164.33</b>	0	-	<b>15.25</b>	<b>7.75</b>
<i>Acanthaster planci</i>	0	-	0	-	0	-
<i>Linckia</i>	<b>66.67</b>	<b>27.39</b>	<b>68.57</b>	<b>67.14</b>	<b>475.00</b>	<b>144.43</b>
Other Asteroidea	4.44	4.71	11.43	7.97	10.00	7.00
Total Asteroidea	71.11	27.18	80.00	72.42	485.00	140.31
<i>Pearsonothuria graeffei</i>	<b>22.22</b>	<b>10.27</b>	<b>74.29</b>	<b>14.69</b>	<b>25.00</b>	<b>16.04</b>
<i>Holothuria atra</i>	17.78	10.27	0	-	0	-
Other Holothurians	4.44	4.71	5.71	6.17	5.00	5.35
Total Holothurians	44.44	19.29	80.00	16.33	30.00	15.65
Lobster	0	-	0	-	0	-
Anemone	0	-	645.71	503.27	25.00	17.96
<i>Tridacna</i>	<b>53.33</b>	<b>22.36</b>	<b>11.43</b>	<b>12.34</b>	<b>25.00</b>	<b>21.29</b>
<i>Octopus</i>	4.44	4.71	0	-	0	-
<i>Charonia tritonis</i>	0	-	0	-	0	-
<i>Cassia cornuta</i>	0	-	0	-	0	-
<i>Lambis</i>	13.33	7.07	5.71	6.17	10.00	7.00
<i>Cypraeidae</i>	<b>57.78</b>	<b>26.56</b>	<b>11.43</b>	<b>7.97</b>	<b>5.00</b>	<b>5.35</b>

Invertebrate categories highlighted in bold in Table 4 are presented graphically in Figures 14 – 16 for Echinoderms and Figure 17 for Molluscs. Herbivorous urchins were generally

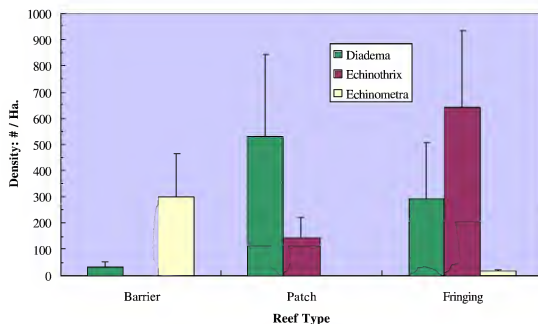
more abundant on patch or fringing reef sites than barrier reef sites (Figure 14) with the exception of *Echinometra*, which was recorded at the northern end of Nosy Hao (Valleys) but not at the other two barrier reef sites. Statistical comparison of urchin densities revealed a significant difference in the abundance of *Echinothrix* between reef types but not for the other two genera (Table 5). *Diadema* were recorded more often on patch and fringing reefs than on barrier reef sites but counts were not significantly different statistically.

**Table 5 Statistical Comparison of Invertebrate Densities between Reef Type.**  
(Significant differences are highlighted in bold)

Oneway ANOVA on  $\sqrt{x + 0.5}$  transformed data. (df = 2, 21; F critical = 3.47) with a Tukey test to identify significant differences ( $p < 0.05$ ) between groups (n.s. = not significant).

Invertebrate	F	P	Comparison Between Reef Type		
			Barrier x Patch	Barrier x Fringing	Patch x Fringing
Diadema	1.47	0.253	-	-	-
<b>Echinothrix</b>	<b>5.33</b>	<b>0.013</b>	n.s.	<b>F &gt; B</b>	n.s.
Echinometra	2.54	0.103	-	-	-
<b>Linckia</b>	<b>9.77</b>	<b>0.001</b>	n.s.	<b>F &gt; B</b>	<b>F &gt; P</b>
<b>Pearsonothuria graeffei</b>	<b>5.56</b>	<b>0.011</b>	<b>P &gt; B</b>	n.s.	<b>P &gt; F</b>
Tridacna	2.09	0.148	-	-	-
<b>Cypraeaidea</b>	<b>4.10</b>	<b>0.031</b>	n.s.	<b>B &gt; F</b>	n.s.

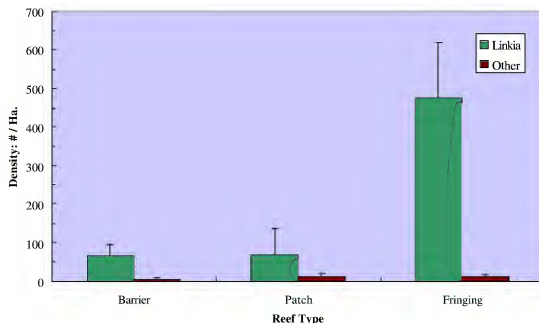
**Figure 14 Density of herbivorous sea urchins for three reef types at Andavadoaka (Mean values + S.E.)**



There was a highly significant difference in the densities of *Linckia* between reef types (Figure 15, Table 5). This genus dominated the sea-star fauna at most survey sites but was

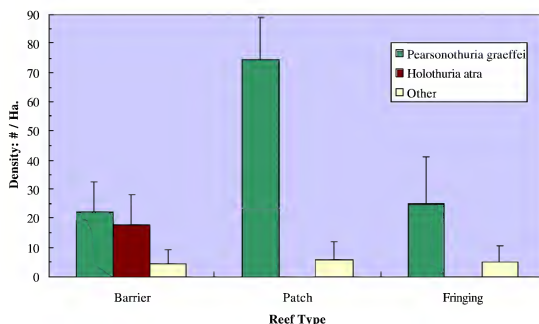
significantly more abundant at fringing reef sites than at the other two reef types (Table 5).

**Figure 15** Densities of large starfish for three reef types at Andavadoaka (Mean values + S.E.)



For holothurians, one species (*Pearsonothuria graeffei*) was recorded most often and was significantly more abundant at patch reef sites than at either fringing or barrier reefs (Figure 16, Table 5). Few individuals of other holothurian species were seen.

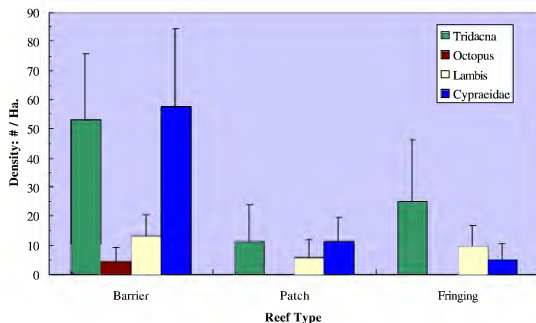
**Figure 16** Holothurian densities at Andavadoaka (Mean values + S.E.)



Lastly, a comparison of molluscan densities for four selected taxa indicates that giant clams (*Tridacna*) and large cowries were recorded more often on barrier reefs. However,

only large cowries, in particular *Ovula ovum*, were significantly more abundant at barrier reef sites than at fringing reefs (Table 5). Although considerably more *Tridacna* were recorded on barrier reef sites there was no significant difference in densities of giant clams between reef types.

**Figure 17**      **Densities of selected molluscs for reef types at Andavadoaka**  
(Mean values + S.E.)



## DISCUSSION

Routine monitoring of coral reefs by Blue Ventures between September 2004 and June 2005 has been documented in some detail for coral reef benthic composition, reef fish abundance and macro-invertebrate density (Nadon et al., 2005). In this section we will not focus on the aspects that have been previously reported but concentrate on the more detailed information that has been collected, particularly for the types of hard coral (lifeform and genera) that are present and the biomass of the main reef fish families. Where major differences in data trends are found for similar criteria studied then these will be highlighted and discussed briefly. However, the two studies are not strictly comparable as we assessed 9 permanent sites during this study over a short time period (10 days) while Nadon et al. (2005) assessed 11 sites over a 10 month period.

### Benthic Composition

Data collected for total hard coral cover is in good agreement with that collected previously by Blue Ventures (Nadon et al., 2005). The patch reef complex to the south-east of Nosy Hao reef contains the highest cover of hard corals while barrier reef sites have intermediate levels and fringing reefs the lowest cover. Patch reefs are also the most complex in terms of micro-topography which can be largely attributed to the greater range of hard coral life-forms present. The higher level of physical complexity provides a greater range of microhabitats for coral reef fauna, particularly reef fish and motile invertebrates.

Barrier reef sites were topographically complex at the macro-level with the presence of well-established spur and groove formations. The high energy environment is characterised by relatively low hard coral cover dominated by encrusting and massive colonies, more adapted to the extreme physical conditions of surge and swell in shallow waters (<10m depth). Calcified algae, particularly crustose types (CCA) are prevalent here and coverage was significantly higher for this reef type.

Fringing reef sites are the most sheltered of the three reef types and usually contain a range of hard coral lifeforms including branching, tabulate and foliose colonies. The overall low hard coral cover and lack of coral topographical diversity for fringing reefs at Andavadoaka can be attributed to previous coral bleaching events. There have been severe bleaching events caused by elevated sea surface temperatures along this coast of Madagascar in recent years, particularly in 1998 and 2000. Bleaching mortality was high and extended to a depth of 10 metres. These events have caused the rapid decline of hard coral cover on fringing reefs in the region. However, the presence of large, intact and living colonies of *Pavona clavus* along the nearshore reefs is encouraging. These areas act as localized havens for remaining reef fish populations and should be considered for protection in any management discussions.

The overall lack of *Acropora* coral cover and diversity on barrier and fringing reefs is also a symptom of previous bleaching mortality events. Usually dominant branching forms of this genus are extremely susceptible to bleaching and mortality caused by a low tolerance to temperature changes (Sheppard et al., 2000). The demise of *Acropora* after the 1998 bleaching event has been well documented in the central and Western Indian

Ocean (McClanahan, 2000; McClanahan, et al., 2001). Although more common at patch reef sites *Acropora* colonies still only covered up to 10 % of available substratum at this reef type. *Acropora* colonies on patch reefs may have been affected to a certain extent by phenomena such as bleaching or tropical storms, particularly at the slightly shallower site ('007'). A marked decrease of hard coral cover was recently observed at another patch reef site ('Fish Bowl') near Andavadoaka after the region was affected by a cyclone in January 2006 (A. Curd, pers. obs.). At barrier reef sites there was some indication of recovery with small encrusting and submassive colonies of *Acropora* present at all sites surveyed. Recovery at fringing reef sites was not evident and is a cause for concern. These nearshore reefs are the most accessible and exploited of the three reef types. It is worth considering reef restoration techniques for the nearshore reefs as a means to accelerate hard coral recovery. A potential technique involving transplanting recruits on plates is proposed by Fenner (2005) in Appendix 1.

Non-calcified algal cover was particularly high on fringing reefs. Nearshore reefs are used more intensively than offshore reefs by the local population for fishing and gleaning. One of the fringing reef sites (Half Moon) was the only location where blue-green algae was recorded at notable levels. This may be an early indicator of nutrient elevation on nearshore reefs close to areas of human habitation. Nutrient and solid waste pollution along the coast warrants further investigation and requires careful consideration in any future development plans for the region.

### **Reef Fish Biomass**

Estimates of the biomass of the major reef fish families indicate that there are considerable differences in the composition and total weight of the reef fish fauna between reef types. Patch reefs contain the highest overall biomass of reef fish, followed by barrier reefs with fringing reefs recording the lowest levels (total for 14 families). Nearshore fringing reefs had consistently high biomass of Pomacentrids and Labrids compared to patch or barrier reefs. Other families (Acanthurids, Caesionids and Lutjanids) showed both high inter-site and intra-site variation in abundance and biomass on the same reef type suggesting that the fish fauna are patchily distributed, particularly for some Acanthurids, pelagic schooling families such as Caesionids, and more sedentary schools of Lutjanids.

Comparison with other studies of reef fish biomass in Madagascar and the Western Indian Ocean region is possible to a certain extent. Estimates of reef fish biomass in northwest Madagascar (Maharavo, 2005) are considerably higher than our estimates for Andavadoaka. Maharavo reported a mean biomass of 182.3 tons/km<sup>2</sup> compared to our estimates for Andavadoaka reefs of 33.5–53 tons/km<sup>2</sup>. Although fishing pressure is likely to be higher in southwest Madagascar than in the northwest, which will explain some of the difference in estimates, it is also likely that differences in the conversion factors used to estimate biomass from fish length are causing some of the disparity.

A better comparison can be made with estimates of fish biomass for East African reefs as more similar methods were employed to calculate biomass for fish families (McClanahan, 1994; McClanahan and Kaunda-Arara, 1996). Studies in Kenya by McClanahan and co-workers have focused on the nearshore shallow lagoonal reefs which are comparable to the nearshore fringing reefs in this study. Estimates for Andavadoaka's fringing reefs



(335.6 kg/ha  $\pm$  126.9 SE) are similar to those for a moderately fished lagoonal reef in Kenya (McClanahan and Kaunda-Arara, 1996) or Tanzania (McClanahan et al., 1999). For offshore reefs (barrier and patch) our estimates of 377.4  $\pm$  41.4 kg/ha and 530.2  $\pm$  161.4 kg/ha respectively are comparable to those collected on seaward reefs (640  $\pm$  170 kg/ha) at Beheloka in southwest Madagascar (Woods-Ballard et al., 2003) which were also regarded as moderately fished. Therefore we can suggest that reefs at Andavadoaka are currently subject to moderate fishing pressure with higher pressure exerted on fringing reefs than barrier reef sites. There is also considerable variation in fishing pressure between individual sites for barrier reefs depending on position and proximity to fishing villages. For example fishing effort is higher at the northern end of Nosy Hao (Valleys) than at the more exposed southern end (Shark Alley).

Estimates for Scarid biomass appear to be considerably lower at Andavadoaka on all reef types than at Beheloka (Woods-Ballard et al., 2003) or for moderately fished reefs in East Africa (McClanahan, 1994; McClanahan et al., 1999). This may be an indication that fishing pressure is beginning to significantly influence the reef fish fauna at Andavadoaka. However, more extensive monitoring work should be conducted to verify this suggestion. Some reef fish such as large piscivores (e.g. Serranids) require a larger sampling area to reliably estimate their biomass. The timed swim method was originally proposed to estimate these larger, more mobile species but was not undertaken because of a lack of trained personnel and diving limitations. We recommend that the next detailed monitoring completed at Andavadoaka undertakes timed swim assessments, as well as belt transects, to reliably estimate the biomass of larger reef fish.

## Macro-Invertebrates

Timed swims are also useful for estimating densities of particular invertebrates such as holothurians, giant clams and large gastropod molluscs. Our estimates collected from belt transects were subject to considerable variation which may have been reduced for the low-density targets by using the 'timed swim' method. The variability of the data between transects contributed to the lack of significant differences in densities of targeted invertebrates between reef types (e.g. *Tridacna*). However, some differences were apparent, namely the higher density of *Linckia* seastars on fringing reefs compared to other reef types, the higher density of *Pearsonothuria graeffei* on patch reefs and the higher numbers of large cowries (*Ovula ovum*) recorded on barrier reef sites. The higher densities of *Linckia* at fringing reefs may be related to a decrease in predation of these seastars caused by reduced populations of their natural predators such as Balistids. This in turn may be an indirect effect of overfishing on the nearshore reefs at Andavadoaka. Densities of herbivorous urchins were also highest at fringing reefs and appear to be greater in shallow water (< 5m) which was not surveyed during this assessment (S. Harding; pers. obs.) but could also be an indication of overfishing of urchin predators such as Balistids and Labrids (see McClanahan and Shafir, 1990).

Sea cucumbers have been exported from Madagascar for the international market since the early 20<sup>th</sup> century (Conand and Mara, 2000). Collectors are known to operate along the coast between Toliara and Morombe with most species of sea cucumber harvested by free diving or using SCUBA. Local fishers at Andavadoaka also harvest sea cucumbers when gleaning (Langley, 2006). The higher density of *Pearsonothuria graeffei* at the patch reef sites may indicate that these small patch reefs are not yet known to collectors. Alternatively, the habitat at these sites (high hard coral cover and more complex micro-

topography) may support a higher density of this species than at the barrier or fringing reefs. However, it is known from local fishers that sea cucumber numbers have decreased dramatically since collection began, primarily on the nearshore reefs (Langley, 2006) although *P. graeffei* is not a species previously preferred by collectors.

One striking difference between this study and the former one documented for Andavadoaka (Nadon et al., 2005) was that we did not record a single triton shell (*Charonia tritonis*) during belt surveys whilst the aforementioned study reports that triton shells were recorded on all reef types. We assessed 6000 m<sup>2</sup> for invertebrate counts during this study while Nadon et al. (2005) covered 5560 m<sup>2</sup> but over a much longer time period. Triton shells, particularly *Charonia tritonis*, are sold in Toliara as part of the ornamental shell trade industry (Wells, 2005) and are very likely targeted in the Andavadoaka region. The difference may partly be due to seasonal changes in abundance at the sites visited but mis-identification of the species may also be a factor.

## **Biodiversity Assessments**

The studies included with this report by Fenner, Allen and Barrere (Appendices 1-3) provide a detailed insight into the faunal diversity of the Andavadoaka region for hard corals, reef fish and molluscs respectively. In this section we will briefly highlight a few main points from these assessments. Further detail can be found in the individual reports.

### **Hard Corals**

A medium diversity of hard corals (164 species) was found at Andavadoaka (Fenner, 2005: Appendix 1) which was more than for previous studies in the southwest of Madagascar (113 species; Pichon, 1978) and similar to levels found in Mozambique (151 species; Reigl, 1996). However, the total was considerably less than that recorded for northwest Madagascar by Veron and Turak (2003) who reported 323 species. Of the 164 species found at Andavadoaka 4 species are regarded as rare (Appendix 1, Table 3) and were recorded across the range of reef types, 19 species were new records for Madagascar (Appendix 1, Table 4) and 16 species had their geographical ranges extended (Appendix 1, Table 5).

Only 21 species of *Acropora* were reported for Andavadoaka, which is markedly less (33%) than the total Veron and Turak (2003) recorded in north-west Madagascar (63 species). This striking fact and the lower total diversity for hard corals are most likely caused by the extensive mass bleaching events in 1998 and 2000 which occurred all along the southwest coast but did not effect the northwest coast of Madagascar.

In terms of the distribution of hard coral diversity at the sites visited at Andavadoaka similar diversity of 107 – 110 species was recorded at all three main reef types (Table 6). However, fringing reefs had the greatest number of species that were recorded at only one reef type, followed by barrier reefs and lastly patch reefs. For the latter reef type, most of these species (69%) were in one family, the Acroporidae.

**Table 6 Comparison of biodiversity between main reef types for hard corals and reef fish at Andavadoaka**

Taxa	Criteria	Reef Type		
		Barrier	Patch	Fringing
Hard Corals	Total No. Species	109	110	107
	No. species at one reef type	18	13	20
	% species at one reef type	16.51	11.82	18.69
Reef Fish	Total No. Species	225	174	218
	No. species at one reef type	44	21	52
	% species at one reef type	19.56	12.07	23.85

## Reef Fish

The total of 386 species of reef fish recorded (Allen, 2005: Appendix 2) indicates that Andavadoaka can be regarded as a region with medium reef fish diversity. The fauna at Andavadoaka is very similar to that described for northwest Madagascar (Allen, 2003). Although fewer species were recorded at Andavadoaka, most of the species recorded only in the northwest were either rarely encountered or cryptic species collected with rotenone, which was not used in Andavadoaka. A comparison of predicted totals for reef fish using the Coral Fish Diversity Index (CFDI) after Allen (1998) indicates that similar approximate totals are expected; 529 species for Andavadoaka (Allen, 2005: Appendix 2) and 576 species for northwest Madagascar (Allen, 2003). A total of 66 species were identified at Andavadoaka which were not seen in the northwest and a total of 20 species were new records for Madagascar (Allen, 2005: Appendix 2).

A total of 3 species reported at Andavadoaka are presently endemic or near endemic to Madagascar (Table 7). In addition a new undescribed species of wrasse (*Pseudocoris* sp.) was recorded at Andravamaïke, the deep offshore patch reef (Allen, pers. comm.). It is likely that other nationally or regionally endemic species may be present at Andavadoaka but were not seen during the surveys. A number of these are cryptic species which were not accurately assessed during our mission and require the use of rotenone for collection.

**Table 7 Endemic or near endemic fishes of Madagascar reported at Andavadoaka**

Family	Species	Known Distribution
Caesionidae	<i>Caesio</i> sp. 1	Madagascar
Pomacentridae	<i>Pomacentrus caeruleopunctatus</i>	Madagascar
Pomacentridae	<i>Amphiprion latifasciatus</i>	Madagascar & Comores

Comparison of reef fish diversity between the main reef types at Andavadoaka (Table 6) indicates that there are different species assemblages at barrier, patch and fringing reefs, which was also confirmed statistically by Nadon et al. (2005). In particular, almost one quarter (24%) of all species recorded on fringing reefs were not seen on either barrier or patch reef sites. This emphasizes the need to protect all reef types and their associated habitats in any conservation plans in order to maximize species protection.

The absence of fish species closely associated with high coral cover and diversity (the cardinalfish *Cheilodipterus artus* and the filefish *Oxymonacanthus longirostris*), that were commonly seen in northwest Madagascar, may indicate that the reduction in live hard

corals through bleaching mortality at Andavadoaka has resulted in the local reduction or loss of these specialist reef fish species.

Other more obvious fish fauna were also rare or absent in the Andavadoaka region. During the monitoring trip only one white-tip reef shark (*Triaenodon obesus*) was observed while no humphead wrasse (*Cheilinus undulatus*) or bumphead parrotfish (*Bolbometopon muricatum*) were seen. There have been occasional sightings of sharks (*Galeocerdo cuvier* and *Sphyrna lewini*) at offshoer sites in the Andavadoaka region in the past (recorded in the Blue Ventures photo library) but these species sightings are very rare. Sharks are targeted by specialist local fishers for the shark fin trade (S. Andramanitra, pers. comm.). Reef fish such as humphead wrasse and larger Serranids are also caught as bycatch in the large-mesh gill nets used by shark fishers. There are, however, regular sightings of a pair of Humphead Wrasse at 'Shark Alley' at the southern end of the Nosy hau reef (A. Curd, pers. comm.).

## **Molluscs**

The assessment of the molluscan fauna at Andavadoaka identified 238 species at 19 sites covering a range of coastal habitats over a period of five days (Barrere, 2005: Appendix 3). The sites visited for this assessment differed slightly from the sites surveyed for coral reef monitoring and the other biodiversity assessments (hard corals and reef fish). In particular, no observations were made on the patch reef complex southeast of Nosy Hao reef. We cannot therefore make the same comparisons between sites and reef types for molluscs as were made for the other biodiversity datasets.

The total count of 238 species in five days indicates that the region has a high diversity of marine molluscs. A similar assessment in northwest Madagascar over 16 days produced a total of 525 species (Wells, 2003). It therefore follows that a more extensive assessment of molluscs in the Andavadoaka region is likely to result in a count of 400-500 species (Barrere, 2005). A full list of the species identified at Andavadoaka is available in Appendix 3.

In terms of the habitats assessed a number of notable observations were made. Firstly the shallow (0-5 m) reef flat areas around Nosy Hao and Nosy Fasy support high densities of the cowrie *Cypraea annulus*, giant clams (*Tridacna* spp.) and conch shells (*Lambis* and *Strombus* spp.). Giant clams are of particular importance as they are listed as a protected species under CITES and were observed to reach a density of 10 individuals / 100 m<sup>2</sup> on parts of the reef flat (Barrere, 2005). On the outer reef slopes (= barrier reef sites) a high diversity and abundance of nudibranchs was noted. A high density of bivalve molluscs (*Anadara* spp. and *Donax* spp.) was recorded in the sandy lagoonal areas between the barrier and fringing reefs. Two families were notable by their absence: Bursidae and Turridae, but this could be a factor of the limited time spent on the survey. A more extensive assessment over a longer time period is bound to substantially increase the molluscan species list for the Andavadoaka region.

## **Recommendations for Conservation and Management**

The data collected during this study provides a detailed baseline for the condition of coral reefs at Andavadoaka for both the health and status of the main reef types and the level of biodiversity present. This information enhances the marine biological information previously collected at Andavadoaka (Nadon et al, 2005). Using some of the key findings of our assessment we can make recommendations for conservation and management of

the marine environment so that sites of high biodiversity and habitats in good condition are considered for protection.

One of the main outcomes of this more detailed study is to reinforce the fact that any marine protected area (MPA) that is set up in the Andavadoaka region must incorporate all habitats across the range of reef types in order to protect the greatest number of species. Table 8 summarises the areas that should be included within one or more MPA's at Andavadoaka with justification for the protection. Although all reef habitats need appropriate conservation the patch reef complex adjacent to Nosy Hao reef is one particular location that merits full protection (i.e. no fishing) as it is the only known location with high cover of hard corals and the presence of mature colonies of Acroporidae (*Acropora* and *Montipora* spp.) in the region.

Although not fully assessed during this study the deeper offshore patch reefs should also be considered for protection in the near future which could follow on from the initial MPA designation at Andavadoaka. Our preliminary assessment at Andravamaïke revealed a unique habitat diverse in soft corals and sponges which supports and attracts a rich fish fauna including large schools of *Caranx sexfasciatus* (S. Harding; pers. obs.) and large individuals of a number of families, including groupers (Serranidae), moray eels (Muraenidae) and triggerfish (Balistidae). These reefs are currently too far from land to be fished regularly by the local population but are likely to become more accessible as fishing gear improves (i.e. through the provision of outboard engines for local fishers).

**Table 8 Summary of areas recommended for protection at Andavadoaka.**

Reef Type / Habitat	General or Specific Location	Justification
Representative areas of all reef habitats.		Species assemblages unique to each main reef type and their associated habitats.
Patch Reef Complex	Recruitment, THB and 007 patch reefs.	High levels of: <ul style="list-style-type: none"> <li>▪ hard coral cover and diversity, particularly for Acroporids (locally)</li> <li>▪ reef fish biomass (Lutjanids / Lethrinids)</li> <li>▪ Targeted invertebrates (Holothurians)</li> </ul>
Outer reef slope around offshore islands (barrier reefs)	Shark Alley / southern end of Nosy Hao reef	High reef fish diversity and biomass (Acanthurids), high densities of macro-invertebrates (e.g. <i>Tridacna</i> spp.)
Fringing reefs – areas with large <i>Pavona clavus</i> colonies	Coco Beach / south of Half Moon	Localised high hard coral cover and fish biomass.
Shallow reef flats around offshore islands	Nosy Hao / Nosy Fasy	High density of giant clams ( <i>Tridacna</i> spp.). Foraging area for octopus; protection from gleaning
Deeper offshore patch reefs	e.g. Andravamaïke	High reef and pelagic fish biomass, unique habitat, new / unrecorded species.

Other more general recommendations for the management of the coastal zone and its resources are as follows:

- Coral reef monitoring at the level completed for this study needs to continue on a regular basis (annually or biannually) in order to monitor coral reef status, including the effect of the proposed MPA on marine habitats and resources.
- Environmental monitoring should include an assessment of nutrient levels on nearshore reefs adjacent to local villages and resorts / hotels.
- Potential alternative sources of income for local fishers need to be further investigated and put in place if viable. Current suggestions include seaweed farming (*Eucheuma*), small-scale pearl oyster farming (*Pinctada margaritifera*) and income through tourism (local tour guides).
- Small-scale coral reef restoration projects need to be considered to determine whether it is feasible to accelerate recovery for fringing reefs, for example, through coral transplantation (see Fenner, 2005: Appendix 1).
- Octopus fisheries management through the full rotational closure of shallow reef areas needs further investigation. Results from the current practice of closing an area for 4-6 months are encouraging but may not be sufficient to maintain the fishery. Rotational closure of two or three areas over 12 months will ensure that an area of reef flat is always closed to octopus fishing at any one point in time.
- Fisheries management practices should be considered and incorporated into the multiple zoning scheme for the MPA. Destructive fishing practices such as beach seine netting need to be controlled or stopped completely.
- Existing coastal conservation programs in Madagascar should be further consulted to learn 'best practise' for the successful execution of management plans at Andavadoaka. Examples are MPA management at Masoala and Mananara-Nord National Parks and coastal zone management in Antongil Bay.
- The capacity for local communities to manage their own MPA's and fishing co-operatives needs to be increased through appropriate training schemes and workshops.
- A regional management committee representing local stakeholders (fishers, tourism operators etc.) and interested parties (e.g. NGO's, local government, commercial fishing companies) should be considered for the Andavadoaka coastal zone.

It is likely that a combination of full and partial protection of marine areas at Andavadoaka will be the most acceptable solution for stakeholders and project partners. A zoning scheme incorporating permanent no-take areas with limited fishing (gear or time restrictions) and open access areas is recommended. The details of position and designation will need to be discussed in depth with the fishing communities involved and factors such as existing fishing grounds, local customs and taboos (fady's) all need to be taken into account. It is very important that the final management plan for the region is a combination of conservation recommendations and the wishes of the local stakeholders. It is also critical that the local communities completely understand why conservation measures are being put in place, fully support the idea of an MPA and are completely involved in the designation and management processes.

## **ACKNOWLEDGEMENTS**

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## APPENDICIES

### APPENDIX 1

#### **Hard Coral Diversity Survey, Andavadoaka, Southwest Madagascar.**

Report for the Wildlife Conservation Society Marine Program, Madagascar and Blue Ventures, UK as part of the Andavadoaka Project.

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#### Executive Summary

- A list of corals was compiled for 10 sites near Andavadoaka, SW Madagascar. The survey involved about 20 hours of scuba diving by D. Fenner to a maximum depth of 31.5 meters.
- The reefs of the Andavadoaka area have a medium diversity coral fauna. A total of 164 species in 55 genera of hard corals (155 species and 50 genera of zooxanthellate Scleractinia) were observed during the present survey, including seven species that were found only in the Blue Ventures coral collection on site. This is slightly more than found by the author in a similar study at Rodrigues Island, Mauritius (140 species in 40 genera). It is also much more than the total known in Hawaii (66: Fenner, 2005). However, it is less than the number found in similar studies by the author in American Samoa (220 species), in Danjungan (236), and Cagdanao (234) Philippines, Leyte Island, Philippines (264), and eastern Australia (257), and significantly less than from eastern Papua New Guinea (332). However, these numbers do not reflect equivalent search time, area, or effort. The number 164 is approximate, due to difficulties in identifying corals.
- The total number of Scleractinian species found (155) in this study is more than that found in the first study of the Tulear region (113 species: Pichon, 1978), and in South Africa (96 species: Riegl, 1996), and similar to that reported from southern Mozambique (151 species: Riegl, 1996), but considerably less than the 323 species found by Veron and Turak (2003) in northwestern Madagascar, or the total known from Madagascar (380). The corals on the reefs of SW Madagascar have suffered considerable damage from mass coral bleaching in 1998 and 2000. Coral cover was reduced a great deal, making it much more difficult to find some species, and possibly making some species locally extinct. The damage to coral populations may have contributed to the low species count. Coral populations in the north are reported to be in good condition (Veron and Turak, 2003; S. Harding, personal comm.) In addition, there may be a latitudinal gradient within Madagascar, though a latitudinal gradient is not apparent in reef fish diversity data (G. Allen, personal comm.), so this seems less

likely. In addition, the different studies did not have equivalent search time, area, effort, or personnel.

- The number of species found after 10 one-hour dives at different sites was 133 species, which is much more than in Hawaii after the same number of dives (about 35), more than in Rodrigues (98 species), slightly less than in American Samoa (147), less than in Peninsular Malaysia (166), Sarawak, Malaysia (170), the Andaman Islands (180), the Great Barrier Reef (190), Fiji (203), and the average of 12 sites in the Coral Triangle (222 species). The number in Madagascar after 10 dives was 60% of that in the average Coral Triangle site.
- The number of species at individual sites ranged from 28 to 64, with an average of 49 per site. In Rodrigues, there was an average of 34 species per site. Sites in Hawaii average about 18 species per site, Fiji averages 70 species per site, and both American Samoa and eastern Australia average 71 species per site. The average number per site for 13 areas in the “Coral Triangle” area of highest diversity was 94.4 species per site. Thus, the diversity was 52% of that in the area of highest diversity, and 2.7 times as diverse as a low diversity area (Hawaii), and 44% higher than that in Rodrigues.
- The coral diversity of SW Madagascar is much greater than in Hawaii, greater than in Rodrigues, but less than that in Malaysia, the Andaman Islands, American Samoa, Fiji, the Great Barrier Reef, and the Coral Triangle.
- 53% of the species found have ranges that extend north, west and east, 30% have ranges that extend in all four directions, 14% have ranges that extend north and east, and 2.5% have ranges that extend only eastward.
- 44% of the species shown by Veron (2000) to have SW Madagascar within their range were found in this study, but only 24% of the *Acropora*. *Acropora* is one of the most sensitive genera to bleaching. The lower percentage of *Acropora* found is consistent with the possibility that mass coral bleaching had removed some species or made them so rare that they could not be found in a brief study. This is consistent with the finding of G. Allen that fish diversity is similar to that in northern Madagascar, and suggests that the cause of the low diversity finding is mass bleaching, not a latitudinal gradient within Madagascar.
- *Acropora*, *Fungia*, *Montipora*, *Favia*, *Porites*, *Pavona*, and *Goniastrea* were the genera richest in species, with 21, 10, 9, 7, 6, 6, and 6 species, respectively. This is typical of rich Indo-Pacific reefs, except that *Montipora* normally has more species than *Fungia*, and *Porites* more species than *Favia*. Mass bleaching may have caused differential mortality in some of these genera, causing deviations from the normal relative generic diversity.
- The overwhelming majority (95%) of corals on these reefs are zooxanthellate Scleractinia, with only a few non-scleractinian and azooxanthellate species, as is typical of Indo-Pacific reefs.
- 4 rare species were found.

- A total of 16 species were found which are outside the published ranges for those species.
- A total of 19 species were found which were not previously reported for Madagascar, bringing the total number of species of coral known in Madagascar to 400 species. Several of the 20 identifications are tentative.
- Four species were found that could only be identified to genus, and may possibly be new species. Much more study will be required to determine if they are new species, including collecting samples and studying their cleaned skeletons. Some of these may be previously named but not be well known.
- General observations revealed that most of the reefs had been devastated by mass coral bleaching and undergone a phase shift from coral to algae, but that the Recruitment patch reefs were in very good shape. A high priority would be to protect the patch reefs so they may help reseed surrounding reefs. Since they survived the previous mass bleaching for unknown reasons, they may also be more resilient to future mass bleaching, which is another reason to protect them. There is an urgent need to increase herbivores by reducing fishing and decrease nutrient runoff from villages and resorts. Doing so might help bring the algae under control and increase coral settlement, and would increase resilience to further coral deaths from future events.

## Introduction

The following is a report of the reef coral fauna of 10 sites in the Andavadoaka area of SW Madagascar, based on results of the author's observations during a visit to the Blue Ventures base at Coco Beach Resort near Andavadoaka village in November and December, 2005, organised and sponsored by the Wildlife Conservation Society Marine Program Madagascar and part funded by Conservation International..

The principle aims of the coral survey was to provide an inventory of the coral species growing on reefs and associated habitats and compare the coral fauna on different sites. The primary group of corals is the zooxanthellate scleractinian corals, that is, those that contain single-cell algae and which contribute to building the reef. Also included are a small number of zooxanthellate non-scleractinian corals which also produce large skeletons which contribute to the reef (e.g., *Millepora* and *Tubipora*: fire coral and organ-pipe coral, respectively), and a small number of azooxanthellate scleractinian corals (in genus *Tubastrea*). And lastly, there are a few azooxanthellate non-scleractinian corals (*Distichopora*, *Stylaster*). All produce calcium carbonate skeletons that contribute to reef building to some degree.

The results of this survey facilitate a comparison of the faunal richness of the reefs of SW Madagascar with those of northern Madagascar, Rodrigues Island (Mauritius), the Coral Triangle area (Philippines, Indonesia and Papua New Guinea), and Hawaii, American Samoa, the Great Barrier Reef, and Fiji in the Pacific. However, the list of corals presented below is incomplete, due to the limited number of dives in the survey (about 20 hours of diving and snorkeling at 10 sites), the highly patchy distribution of corals and the difficulty in identifying some species in the water. Corals are sufficiently difficult to identify that there are significant differences between leading experts on some identifications. Visual identifications are tentative and require confirmation from microscopic examination of the cleaned skeletons of collected specimens.

## Methods

Corals were surveyed in about 20 hours of diving in 20 scuba dives by D. Fenner to a maximum depth of 31.5 m. Lists of coral species were recorded at 10 sites, which were dove an average of 2 times each. The basic method consisted of underwater observations, during one 60 minute dive. At the deepest site, dives were limited to about 35 minutes. The name of each species identified was marked on a plastic sheet on which species names were printed. A direct descent was made in most cases to the maximum depth of the reef, which varied from about 10 to 25 m depth. The bulk of the dive consisted of a slow ascent along the reef in a zigzag path to the top of the reef. Sample areas of all habitats encountered were surveyed. Many corals can be identified to species with certainty in the water and a few must be identified alive since they cannot be identified without living tissues. Also, there are some that are easier to identify alive than from skeletons. However, some are difficult to identify in the field or require confirmation from collected specimens. Field guides assisted identification (Veron and Stafford-Smith, 2002; Veron, 2000; Wallace, 1999ab). Additional references supporting identification are listed in references (Best & Suharsono, 1991; Boschma, 1959; Cairns & Zibrowius, 1997; Claereboudt, M. 1990; Dai, 1989; Dai & Lin 1992; Dineson, 1980; Fenner, in preparation; Hodgson, 1985; Hodgson & Ross, 1981; Hoeksema, 1989; Hoeksema &

Best, 1991; Hoeksema & Best 1992; Moll & Best, 1984; Lamberts, 1982; Nemenzo 1986; Nishihira, 1986; Ogawa & Takamashi, 1993, 1995; Randall & Cheng, 1984; Sheppard & Sheppard, 1991; Suharsono, 1996; Veron, 1985, 1986, 1990, 2000; Veron & Nishihira, 1995; Veron & Pichon 1976, 1980, 1982; Veron, Pichon & Wijman-Best, 1977; Wallace 1994, 1997a, Wallace & Wolstenholme 1998). Dive sites are listed in Table 1. The site names are mainly those given by Blue Ventures and correspond to monitoring sites, with the exception of Andraviamaike.

Table 1: Dive sites and numbers of coral species found.

Dive No.	Location; Site Name	Reef Type	No. of coral species
1	Shark Alley	Barrier	50
2	Coco Beach	Fringing	40
3	Nosy Fasy	Barrier	62
4	Nosy Fasy	Barrier	43
5	Andraviamaike	Offshore Deep Patch	28
6	Shark Alley	Barrier	34
7	THB	Patch	42
8	THB	Patch	54
9	Valleys	Barrier	64
10	Valleys	Barrier	63
11	Coco Beach	Fringing	39
12	Coco Beach	Fringing	29
13	Andavadoaka Rock	Fringing	57
14	Andavadoaka Rock	Fringing	45
15	007	Patch	51
16	007	Patch	57
17	Recruitment	Patch	57
18	Recruitment	Patch	55
19	Half Moon	Fringing	66
20	Half Moon	Fringing	50
21	Andraviamaike	Offshore Deep Patch	Not Recorded

## Results

A total of 164 species in 55 genera of hard corals (155 species and 50 genera of zooxanthellate Scleractinia) were found in the survey of these reefs, (Appendix A). All of these species are illustrated in Veron (2000) and Veron and Stafford-Smith (2002). The total of 164 species is more than that found in the first study of the Tulear region (113 species: Pichon, 1978), and in South Africa (96 species: Riegl, 1996), and similar to that reported from southern Mozambique (151 species: Riegl, 1996), but much less than the 323 species found by Veron and Turak (2003) in northwestern Madagascar, and much less than the total of 380 species known from Madagascar (Veron and Turak, 2003). It is, however, slightly more than that found by the author in a similar study at Rodrigues Island, Mauritius (140 species in 40 genera: Fenner et al 2004). It is also much more than the total known in Hawaii (66: Fenner, 2005). It is less than the number found in similar studies in American Samoa (220 species), in Danjuan (236) and Cagdanao (234)

Philippines, Leyte, Philippines (264), and eastern Australia (257), and significantly less than from eastern Papua New Guinea (332). However, many more dives were made in these other surveys, and additional dives increase the number of species found. The present numbers of species are approximate, due to the difficulty in identifying coral species in the water, and the fact that only a few skeletons in a pre-existing collection were examined.

The number of species found after 10 one-hour dives on 10 different sites (counting only the first dive on each site) was 133 species, which is much more than the number found after the same number of hours diving in Hawaii (about 35), more than in Rodrigues (98 species), slightly less than in American Samoa (147), less than in Peninsular Malaysia (166), Sarawak, Malaysia (170), the Andaman Islands (180), the Great Barrier Reef (190), Fiji (203), and the average of 12 sites in the Coral Triangle (222 species). The number in Madagascar after 10 dives was 60% of that in the average Coral Triangle site. These comparisons are much better than those of the total number of species found, since the number of dives and sites was equated, and the same researcher collected all the data. The number of dives or amount of search effort is a particularly powerful variable and must be equated for a valid comparison.

The number of species at individual sites ranged from 28 to 64, with an average of 49 per site. In Rodrigues, there was an average of 34 species per site. Sites in Hawaii average about 18 species per site, Fiji average 70 species per site, and both American Samoa and eastern Australia average 71 species per site. The average number per site for 13 areas in the "Coral Triangle" area of highest diversity was 94.4 species per site. Thus, the diversity was 52% of that in the area of highest diversity, and 2.7 times as diverse as a low diversity area (Hawaii), and 44% higher than that in Rodrigues. The average number of corals found per site, like the number of species found in 10 sites, is equated between these studies, to make a valid comparison. The two methods produce similar results, with 52 and 60% of the diversity in the Coral Triangle.

The coral diversity of SW Madagascar is much greater than in Hawaii, greater than in Rodrigues, but less than that in Malaysia, the Andaman Islands, American Samoa, Fiji, the Great Barrier Reef, and the Coral Triangle. Hawaii is very far east in the Pacific and thus far down the longitudinal diversity gradient in the Pacific, and it is also very isolated. It is not clear why SW Madagascar should have higher diversity than Rodrigues Island. The diversity also appears to be much less than in Northern Madagascar.

The reefs of SW Madagascar suffered considerable loss of live coral during the mass bleaching episodes of 1998 and 2000 (S. Harding, personal comm.). This was apparent in the very low coral cover of most reefs, with some appearing to have lost as much as 99% of their coral cover. The Recruitment group of patch reefs is unusual for Andavadoaka reefs in that it retains very high live coral cover of about 60% (Nadon *et al.*, 2005). The loss of much of the living coral during mass coral bleaching may have driven some coral species close to local extinction, making them much harder to find, that is making the number of species found within a fixed search time such as a one hour dive, much lower. In the present study, 44% of the species shown by Veron (2000) to have SW Madagascar within their range were found in this study, but only 24% of the *Acropora* species. *Acropora* is one of the most sensitive genera to bleaching. G. Allen reports that the diversity of reef fish he found in SW Madagascar to be very similar that he found in NW Madagascar (G. Allen, personal comm.). In NW Madagascar, live coral cover is reported



to be much better (Veron and Turak, 2003; S. Harding, personal comm.). Fish would not be affected by mass coral bleaching like coral populations are. All of these facts are consistent with the view that the lower diversity of corals found in SW Madagascar compared to northern Madagascar is due to mass coral bleaching in the southwest, not due to a latitudinal diversity gradient within Madagascar.

### General faunal composition

The coral fauna consists mainly of Scleractinia. The genera with the largest numbers of species found were *Acropora*, *Fungia*, *Montipora*, *Favia*, *Porites*, *Pavona* and *Goniastrea*. These seven genera account for about 21% of the total observed species (Table 2). (Families are less stable and useful in corals than genera, and thus were not used.)

Table 2: Genera with the greatest number of species

Rank	Genus	No. of species
1	<i>Acropora</i>	21
2	<i>Fungia</i>	10
3	<i>Montipora</i>	9
4	<i>Favia</i>	7
5	<i>Porites</i>	6
6	<i>Pavona</i>	6
6	<i>Goniastrea</i>	6

*Acropora*, *Montipora*, and *Porites* are usually the three most species-rich genera on rich Indo-Pacific reefs. The farther down the list one moves, the more variable the order becomes, with both the number of species and the differences between genera decreasing.

Most of the corals were zooxanthellate (algae-containing, reef-building) Scleractinian corals, with 95% of the corals in this group. There were two species that are azooxanthellate (lacking algae) Scleractinia for 1% of the total, and there were seven corals that were not Scleractinia, for 4% of the total.

### Zoogeographic affinities of the coral fauna

The reef corals of SW Madagascar reefs belong to the overall Indo-west Pacific faunal province, which stretches from the Red Sea and eastern Africa to the Pacific coast of the Americas. A few species span the entire range of the province, but most do not. The area of highest biodiversity in corals ("Coral Triangle") appears to be an area enclosing the Philippines, central and eastern Indonesia, and northern (Hoeksema, 1992) and eastern Papua New Guinea and the Solomon Islands. Diversity declines in all directions from this center, reaching low levels in Hawaii and even lower levels on the Pacific coast of the Americas.

The biodiversity of corals falls off from the Coral Triangle in all directions, reaching 80 species at an island near Tokyo, 65 species at Lord Howe Island southeast of Australia, about 66 species in Hawaii, and about 20 species at Pacific Panama. Species fall-off is significantly less to the west in the Indian Ocean and Red Sea. About 300 species may currently be known in the Red Sea, though this area, like many others, is insufficiently studied to provide accurate figures.

Most coral species found in this area have fairly wide distributions within the Indo-Pacific. A majority of corals have a pelagic larval stage, with a minimum of a few days pelagic development for broadcast spawners (a majority of species), and larval settling competency lasting for at least a few weeks. A minority of species release brooded larvae that may be capable of anything from immediate settlement to a long pelagic dispersal period. 53% of the species found have ranges that extend north, west and east, 30% have ranges that extend in all four directions, 14% have ranges that extend north and east, and 2.5% have ranges that extend only eastward.

### **Estimate of total diversity**

The total number of coral species in SW Madagascar can be estimated by looking at the percentage of the species for which SW Madagascar is within their known range as shown in Veron (2000) which were found in this study. 44% of the species shown to be within their known range in SW Madagascar were found in this study. Dividing the number of species found (164) by 0.44 gives a total of 373 species, which is close to the total known in Madagascar (Veron and Turak, 2003). This depends on the ranges shown in Veron (2000) to be accurate, however, range extensions to these maps are frequently found by the author and others. Thus, the total eventually found is likely to be higher than 373 species, and indeed with the present report the total is now 400 and likely to go higher.

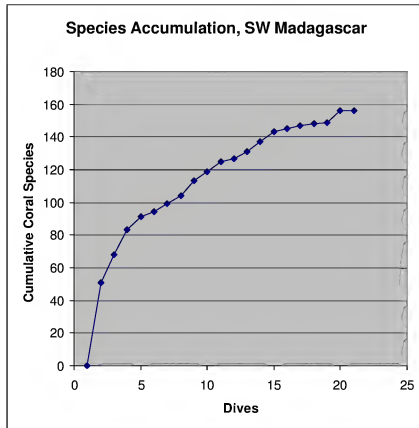
### **Diversity at individual sites**

The number of coral species was highest at Half Moon and Valleys, with 66 and 64 species, respectively. The number of coral species was lowest at Andraviamaike and Coco Beach, with 28 and 29 species, respectively. The dive on Andraviamaike was shorter than on other reefs, reducing the number of species found, and Coco Beach fringing reef had some of the lowest coral cover, making it harder to find many species.

The number of species at all sites is presented in Annexe I.

Species are found quickly at first, but additional species are found at a slower and slower pace as more species are found. Thus there are diminishing returns for additional work, yet species continue to be found.

Figure 1:



### Habitats and Reefs

Corals are habitat-builders and appear to have less niche-specialization than some other groups. Some zonation occurs by depth and exposure to waves or currents. Thus, there are a few corals that are restricted to zones such as very shallow areas, protected areas, deep water, shaded niches, soft bottoms, or exposed areas. However, many corals can be found over a relatively wide range of exposure and light intensity. Corals are primarily autotrophic, relying on the products of the photosynthesis of their symbiotic algae, supplemented by plankton caught by filter-feeding and suspension feeding. Most require hard substrate for attachment, but a few grow well on soft substrates.

The reefs in this study could be divided into fringing, barrier, patch, and deep reefs. The reefs around offshore islands were considered barrier reefs. The fringing reefs averaged 47.8 coral species per dive, the barrier reefs averaged 52.7 species per dive, the patch reefs averaged 52.7 species per dive, and the deep reef had 28 species in the one short dive on it. A one-way ANOVA for the first three groups gave an  $F$  of .39 and  $p = .68$ , so the differences were not significant.

### Dominant Species

Coco Beach fringing reef had a large mass of *Pavona clavus*, and also a large mass of *Galaxea astreata* columns. THB patch reef also had a mass of *Galaxea astreata* columns. 007 patch reef had fields of foliose *Montipora aequituberculata* and a large

mass of *Pavona clavus*. The patch reefs had significant areas of *Porites cylindrica* and a fuzzy branching *Porites* species that was unidentified. At the base of some of the fringing reefs there were significant patches of unattached *Goniopora stokesi* colonies. This species forms small “polyp balls” that have a ball of skeleton in the center, which detach from the parent colony and start a new colony. The patches are likely to be clones, though two tentacle shapes could be distinguished, blunt and thin. The patch reefs especially, and the barrier reefs also, had high amounts of dead coral substrate covered with algae. On the patch reefs, much of it appeared to be dead staghorn *Acropora*, though near the columnar *Galaxea astreata* there were areas of dead columns that were likely from *Galaxea astreata*. This all appeared to be due to the mass coral bleaching in 1998 and 2000.

### Species of special interest

*Stylophora madagascarensis*, a species so far known only from Madagascar (though only described in 2002 and quite possibly will be found outside Madagascar), was quite common. It was described by Veron from the Tulear region, but not found in northwestern Madagascar by Veron and Turak (2003) at all. *Acropora branchi*, which has a small known range extending from South Africa to SW Madagascar, was found on the patch reefs in small numbers. *Horoastrea indica* was not seen in this study, although one sample is in the Blue Ventures collection. Veron and Turak (2003) reported it was common in northwestern Madagascar, but Veron (2000) did not find it at all in Tulear. This is consistent with the findings here.

Several species were found that are uncommon to rare, which are listed in Table 3. All were documented with photographs. *Leptoseris incrustans* and *Millepora foveolata* were rare in the author’s previous research. *Millepora foveolata* is cryptic and difficult to recognize. *Montastrea serageldini* and *Plesiastrea devantieri* are recently described corals (Veron, 2002), which the author had not seen before. *P. devantieri* particularly may not be rare. A puzzling coral that appears similar but not identical to *Blastomussa merletii* may be the new species of *Blastomussa* referred to in Veron and Turak, 2003. It was quite common.

Table 3: Rare Corals

1. *Leptoseris incrustans*
2. *Montastrea serageldini*
3. *Plesiastrea devantieri*
4. *Millepora foveolata*

Twenty species were found that have not been reported previously from Madagascar. Non-scleractinian corals have not been reported previously from Madagascar.

Table 4: New reports for Madagascar (not reported in Veron and Turak, 2003).

“x” indicates a single sighting or tentative identification; “y” indicates a photograph, “z” a skeleton examined.

- |                                  |      |
|----------------------------------|------|
| 1. <i>Acropora crateriformis</i> | x, y |
| 2. <i>Acropora vauhanii</i>      | x    |
| 3. <i>Montipora capitata</i>     | x, y |

4. <i>Montipora corbettensis</i>	y
5. <i>Montipora incrassata</i>	x
6. <i>Montipora vietnamensis</i>	y
7. <i>Goniopora fruticosa</i>	x
8. <i>Mycodium robokakai</i>	x, y
9. <i>Acanthastrea subechinata</i>	x, y
10. <i>Favia bestae</i>	y
11. <i>Favia rotundata</i>	y
12. <i>Goniastrea favulus</i>	x, y
13. <i>Tubipora musica</i>	
14. <i>Millepora dichotoma</i>	
15. <i>Millepora exesa</i>	
16. <i>Millepora foveolata</i>	y, z
17. <i>Millepora intricata</i>	y
18. <i>Distichopora violacea</i>	
19. <i>Stylaster</i> sp.	

Table 5 presents species for which the present SW Madagascar report is an extension of the range shown in Veron (2000) or given in Randall and Cheng (1984) for that species.

Table 5: Range Extensions

1. *Acropora crateriformis*
2. *Montipora capitata*
3. *Montipora capitata*
4. *Montipora vietnamensis*
5. *Fungia granulosa*
6. *Fungia moluccensis*
7. *Acanthastrea subechinata*
8. *Scolymia vitiensis*
9. *Diploastrea heliophora*
10. *Favites bestae*
11. *Leptastrea pruinosa*
12. *Montastrea serageldini*
13. *Oulophyllia bennettiae*
14. *Plesiastrea devanieri*
15. *Millepora intricata*
16. *Millepora foveolata*

A total of four species were recognized which could not be identified to species. Some of these may be discovered to already be named, with their names hidden in obscure literature. There was one species of *Acropora*, two of *Porites*, and one of *Coscinaraea*. In addition, there were several photographs of corals that could only be identified to genus. There may be new species among these, particularly the *Coscinaraea*, since Veron and Turak (2003) indicates that he found a new species of *Coscinaraea*. Considerable time and work, including examining skeletons of samples, will be necessary to document these.

## Overview of the coral fauna

The coral fauna of SW Madagascar was quite a bit less than that reported from northern Madagascar. All the evidence indicates that this is because mass coral bleaching in 1998 and 2000 killed large amounts of some kinds of corals, making some species rare enough to be very hard to find, or perhaps locally extinct. The overall level of diversity that remains was intermediate, about 52-60% of that of sites in the Coral Triangle area of highest diversity. Nearly 400 species may eventually be found in Madagascar.

## Other observations

The only coral disease observed was a colony with some small circular, uniform, white spots, about 1 cm diameter. There is a "White Patch" syndrome on corals that is widespread, but is not known to cause the death of the affected part of the coral. The patches are usually larger than these white spots, about 3-10 cm in diameter, and they are usually polygonal but can be round or oval. These white spots appear to be no threat at all, and in fact the lack of any other coral disease was surprising good news. Many Pacific reefs now have noticeable numbers of diseased corals, such as the author has observed in American Samoa and the Philippines. The most common lethal disease is "White Syndrome," where a band of white moves across a table coral, often in a wedge going around it, followed by a gradient of increasing growth of filamentous green algae. The other common disease is growth abnormalities, often called neoplasms or cancers. They are usually non lethal.

The author saw and photographed "CLOD" = Coralline Lethal Orange Disease. It was seen only once, but the observation and photo are very clear and there is no doubt about the identification. This appears to be a major range extension of this disease, since it was first discovered in the South Pacific and still only known from the Pacific. The disease is caused by a bacterium. The author will be publishing this in an article with Dr. Greta Aeby. Although it has reduced coralline algae considerably in Fiji, it is not known to have caused problems elsewhere. It has been moderately common in American Samoa for quite a while, yet crustose coralline algae continue to have healthy populations there and dominate reef slopes. It does not appear to be a threat.

The author also observed and photographed the "golden noodle algae," *Chrysocystis fragilis*, which has recently been reported to bloom each summer on the Great Barrier Reef. It is in a group of algae called "golden algae" or Chrysophytes, which are so poorly known and rarely reported that they are not even included in algae identification guides. The author has observed it elsewhere, and the observation here is a major range extension for this species. It is not yet known to cause problems. This will also be announced in a publication.

The author also saw and photographed the Skunk Anemonefish, *Amphiprion akallopisos*. This will be used to aid the identification of a similar looking anemonefish in American Samoa, along with photos of *A. sandaracinos* from the Philippines.

## General Observations

Most of the reefs in the area have been badly damaged by mass coral bleaching. They have undergone a phase shift from coral reefs to algae beds. The Recruitment patch reef group retains very high live coral cover, however. The Recruitment patch reef group has the potential to help reseed other nearby reefs with corals, and so should receive a high

priority for conservation measures. In addition, since for some unknown reason they survived the mass coral bleaching, they may be more resilient than the other reefs. Conserving them may keep at least some reefs in the area healthy for as long as possible, helping to reseed other reefs. The mass coral bleaching is not the fault of the people of Madagascar, and is largely outside the control of anyone there. The dead coral is colonized with algae, with few new coral recruits. The few dead corals on the Recruitment reefs have many vigorous new recruits on them, supporting the view that these reefs are largely self-seeding, even though reefs are only a few kilometers apart. Settlement plates placed at different distances from the Recruitment reefs might reveal a pattern showing the source of recruits to be at the Recruitment reefs (as with the Helix Reef on the Great Barrier Reef: Sammarco and Andrews, 1988), and how far the larvae disperse, but this is more of an academic research project than a practical management action. Active work to restore the damaged reefs could use the high recruitment level on the Recruitment Reefs. Objects such as settlement plates could be placed in areas of dead coral and algae (never on live corals) on the Recruitment Patch Reefs. Once the objects had corals settled and growing on them, the objects could then be moved to reefs that have lost most of their corals. Clustering the objects on the recipient reefs would increase the fertilization rates once coral spawning begins, and speed the reseedling of the recipient reefs by the new corals. The objects would need to be secured to the reef. Moving settlement objects has several major advantages over coral transplantation. First, it does no harm to existing corals. This is probably an important first rule, "do no harm." Coral transplantation does harm existing corals. Second, survival during transplantation should be very high, since the corals are not stressed by breakage and are already attached. And third, the method captures coral larvae that would otherwise be lost, and distributes the recruits from a highly productive reef to other reefs much faster than currents seem to be dispersing them. Although only small amounts of coral recruit moving can be done, the clusters of new corals on other reefs can then reseed those other reefs in coming years. McManus et al (2000) noted that the mass coral bleaching of 1998 opened up dead substrate, much as Hurricane Allen did in Jamaica in 1980, followed by the death of the last herbivores (urchins) there in 1983. This was followed by a phase shift to algae bed, which has persisted. McManus pointed out that the same thing may occur on some reefs where corals were killed by mass bleaching. Certainly the dead coral in the Andavadoaka area is covered with a blanket of algae, 5-7 years after the bleaching events, with few recruits. Thus, the algal phase appears to be stable. Overfishing of herbivorous fish, probably coupled with nutrient runoff from rapidly growing villages and resorts, provide conditions conducive to persistence of the algae beds. Poor visibility in the water during our visit is consistent with the view that there is too much nutrient runoff. If herbivorous fish are not allowed to return and nutrient runoff continues, the algae beds may persist for much longer. Increasing herbivores and reducing nutrient inputs increase the resilience of the reefs. If there had been enough herbivores and low nutrients, when the coral died it might have been covered with coralline algae, which would have been followed by coral recruitment and a return to healthy reefs (coralline algae will grow best where wave surge is greatest, and herbivory is greatest). Building herbivore populations and reducing nutrient inputs should be high priorities, though they will not be easy.

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**ANNEXE I: List of all species of Corals recorded at Andavadoaka, SW Madagascar in November / December 2005**

Genera No.	Species No.	SPECIES	New report	photo	sample	SITE RECORDS
1	1	<b><u>Family Astrocoeniidae</u></b>				
		<i>Stylocoeniella guentheri</i> Bassett-Smith, 1890				2R, 9R, 18R
2	2	<b><u>Family Pocilloporidae</u></b>				
		<i>Pocillopora damicornis</i> (Linnaeus, 1758)				1U, 2U, 3U, 7U, 8U, 11R, 13U, 14U, 15R, 17U, 18U, 19U, 20R
	3	<i>Pocillopora dana</i> Verrill, 1864				7U,
	4	<i>Pocillopora eydouxi</i> Milne Edwards & Haime, 1860				1R, 3R, 4R, 7R, 8U, 9R, 10R, 13U, 14R, 15R, 16R, 17U, 18U, 19R, 20R
	5	<i>Pocillopora verrucosa</i> (Ellis & Solander, 1786)		X		3U, 6U, 7C, 8C, 9U, 10U, 13U, 15U, 16U, 17C, 19U
3	6	<i>Seriatopora aculeata</i> Quelch, 1886		X		Collection
	7	<i>Seriatopora caliendrum</i> Ehrenberg, 1834				2U, 4R, 6R, 7C, 9R, 10R, 12R, 13R, 14R, 19R, 20R
	8	<i>Seriatopora hystrix</i> Dana, 1846				5R, 11R, 13R, 19R
4	9	<i>Stylophora madagascarensis</i> Veron, 2002		X	X	1R, 2U, 5R, 7R, 8C, 9R, 10R, 11U, 12U, 13U, 15R, 17C, 18C, 19U, 20U
	10	<i>Stylophora pistillata</i> Esper, 1797				3R, 10R, 17R, 20R
	11	<i>Stylophora subseriata</i> Ehrenberg, 1834				19U, 20R
5		<b><u>Family Acroporidae</u></b>				
	12	<i>Acropora abrotanoides</i> (Lamarck, 1816)				7R, 8U, 15R, 16U, 17R, 18R,
	13	<i>Acropora austera</i> (Dana, 1846)		X		8U, 15R, 16R, 17U, 18U,
	14	<i>Acropora branchi</i> Riegl, 1995		X		16U, 17U, 18U,
	15	<i>Acropora cerealis</i> (Dana, 1846)				19R
	16	<i>Acropora clathrata</i> (Brook, 1891)				4U, 5U, 7U, 8U, 9R, 13R, 14R, 15U, 16U, 17U, 18U,
	17	<i>Acropora crateriformis</i> (Gardiner, 1898)	X	X		1U, 3C, 4U, 5U, 9C,
	18	<i>Acropora cuneata</i> (Dana, 1846)		X		13U,
	19	<i>Acropora cytherea</i> (Dana, 1846)		X		14R, 15R, 16R, 17U, 18U, 19R,
	20	<i>Acropora glauca</i> (Brook, 1892)		X		13C, 14C, 15U, 16U, 17C, 18C, 19U, 20R
	21	<i>Acropora humilis</i> (Dana, 1846) like				7R, 8R, 10R, 11R, 13R, 16R, 17R, 18R, 19R
	22	<i>Acropora insignis</i> Nemenzo, 1967				9R,
	23	<i>Acropora loripes</i> (Brook, 1892)		X		13U, 14R, 16R, 17U, 18U, 19R
	24	<i>Acropora microphthalma</i> (Verrill, 1859)		X		13R, 14U, 18R,
	25	<i>Acropora muricata</i> (Linnaeus, 1758) (=formosa)				2U, 13R, 14R,

	26	<i>Acropora nobilis</i> (Dana, 1846)	like			8U, 17R,
	27	<i>Acropora roseni</i> (Wallace, 1999)		X	X	Several, 17U, 18U
	28	<i>Acropora samoensis</i> (Brook, 1891)				14R,
	29	<i>Acropora secale</i> (Studer, 1878)			X	10R, 14R, 17U, 18U,
	30	<i>Acropora tenuis</i> (Dana, 1846)				2R, 7U, 8U,
	31	<i>Acropora vauhani</i> Wells, 1954		X		7U, 8U, 10R,
	32	<i>Acropora raspy</i> branch				Most sites, 17U, 18U, 19R, 20R
6	33	<i>Astreopora listeri</i> Bernard, 1896			X	13R
	34	<i>Astreopora myriophthalma</i> (Lamarck, 1816)			X	1R, 3R, 6R, 9R, 10R, 13R, 14R, 16R,
	35	<i>Astreopora suggesta</i> Wells, 1954				1R, 4R, 5R, 6R, 7R, 8R, 9R, 10R, 14R, 17R, 19R
7	36	<i>Montipora aequituberculata</i> Bernard, 1897			X	15A, 16A,
	37	<i>Montipora capitata</i> Dana, 1846		X	X	17R
	38	<i>Montipora corbettensis</i> Veron & Wallace, 1984		X	X	4R, 5R,
	39	<i>Montipora incrassata</i> (Dana, 1846)		X		?8R
	40	<i>Montipora informis</i> Bernard, 1897				4R, 7R, 16U, 18R,
	41	<i>Montipora nodosa</i> (Dana, 1846)				?8R
	42	<i>Montipora tuberculosa</i> Lamarck, 1816)				1U, 3U, 4R, 6R, 7R, 8U, 9R,
	43	<i>Montipora verrucosa</i> (Lamarck, 1816)				18R,
	44	<i>Montipora vietnamensis</i> Veron, 2002		X	X	3R, 16U, 17U,
		<b>Family Poritidae</b>				
8	45	<i>Goniopora albiconus</i> Veron, 2002			X	10U, 11R, 13R, 20R
	46	<i>Goniopora pendulus</i> Veron, 1985			X	14R
	47	<i>Goniopora fruticosa</i> Saville-Kent, 1893		X		?73R,
	48	<i>Goniopora somaliensis</i> Vaughan, 1907			X	14R
	49	<i>Goniopora stokesi</i> Edwards & Haime, 1851			X	12C, 13U, 14C, 19C
9	50	<i>Porites cylindrica</i> Dana, 1846			X	14R, 19R
	51	<i>Porites lutea</i> Milne Edwards & Haime, 1851			X	1R, 3R, 10R, 20R
	52	<i>Porites profundus</i> Rehberg, 1892			X	1U, 2U, 3U, 4U, 6R, 7C, 8C, 9U, 19U, 12R, 14R,
						15U, 16U, 17U, 18U, 19R
	53	<i>Porites rus</i> (Forskål, 1775)			X	2R, 3R, 6C, 7C, 9U, 10U, 11R, 15U, 16U, 17U, 18U,
						19R, 20R
	54	<i>Porites</i> massive				1C, 8U, 13C, most others
	55	<i>Porites</i> fuzzy branch			X	6U, 7A, 8A, 15A, 16A, 17U
		<b>Family Siderasteridae</b>				
10	56	<i>Coscinaraea columna</i> (Dana, 1846)			X	1U, 4U, 7R, 8U, 10R, 16R, 17R, 18R,

	57	<i>Coscinaraea crassa</i> Veron & Pichon, 1980	X	X	6R, 9R, , 13R, 16R, 19U
	58	<i>Coscinaraea wellsi</i> Veron & Pichon, 1980	X	X	9R,
	59	<i>Coscinaraea</i> sp. 1	X		8R, 9R, 10U, 17R, 18R, 19U
11	60	<i>Craterastrea</i> cf. <i>levis</i> Head, 1983		X	Collection
12	61	<i>Horoastrea indica</i> Pichon, 1971		X	Collection
13	62	<i>Psammocora explanulata</i> van der Horst, 1922		X	Collection
	63	<i>Psammocora nierstraszi</i> van der Horst, 1921		X	2R, 7R, 20R
	64	<i>Psammocora profundacella</i> Gardiner, 1898		X	1R,2R,3R,4R,6R,7U,8U,9R,10R,11R, 13R, 14R, 15R, 16R, 18R, 19U, 20R
14	65	<i>Siderastrea savignyana</i> Milne Edwards and Haime, 1850		X	Collection
		<b><u>Family Agariciidae</u></b>			
15	66	<i>Gardineroseris planulata</i> Dana, 1846		X	1U, 3U, 4R, 7U, 8R, 10R, 11R, 12R, 13R, 14R, 15R, 16R, 17R, 18R,
16	67	<i>Leptoseris explanata</i> Yabe & Sugiyama, 1941		X	5U, 16, 17U, 18U, 20R
	68	<i>Leptoseris incrustans</i> (Quelch, 1886)	X		10R,
	69	<i>Leptoseris mycetoseroides</i> Wells, 1954		X	1U, 2R, 3U, 5R, 6R, 8U, 9U, 19U, 11R, 13R, 16R, 17R, 18R, 20R
17	70	<i>Pachyseris speciosa</i> (Dana, 1846)		X	1R, 2U, 3U, 4U, 5C, 7U, 8U, 9C, 10U, 11U, 12U, 13U, 14U, 15R, 19U, 20U
18	71	<i>Pavona cactus</i> (Forskål, 1775)			11R, 15R,
	72	<i>Pavona clavus</i> (Dana, 1846)		X	2A, 8C, 15C, 17U, 19U, 20U
	73	<i>Pavona duerdeni</i> Vaughan, 1907		X	1U, 2R, 3R, 6R, 7C, 9R, 11R, 12R, 13R, 15C, 16C, 18U, 19U, 20R
	74	<i>Pavona explanulata</i> (Lamarck, 1816)		X	1U, 2R, 3R, 4R, 5R, 6R, 7R, 8R, 9R, 10R, 11R, 12R, 14R, 15R, 16R, 17U, 18U, 19R
	75	<i>Pavona maldivensis</i> (Gardiner, 1905)		X	4R, 7R, 8R, 11R, 15R, 16U, 17U, 18U, 19U
	76	<i>Pavona varians</i> Verrill, 1864		X	1U, 2U, 3R, 4R, 6R, 7R, 8R, 9R, 10R, 11R, 13C, 15R, 16R, 17U, 19R, 20R
		<b><u>Family Fungiidae</u></b>			
19	77	<i>Cycloseris cyclolites</i> (Lamarck, 1801)	X		10R
	78	<i>Cycloseris tenuis</i> (Dana, 1846)			1R, 3U, 4U, 6C, 8R, 9R, 10R, 14R, 18R, 19R, 20R, 4R,
	79	<i>Cycloseris vaughani</i> (Boschma, 1923)			6R, 7R, 10R, 19R,
20	80	<i>Fungia concinna</i> Verrill, 1864			1R, 2R, 4R, 8U, 10R, 11R, 13R, 15R, 16R, 18R, 19R,
	81	<i>Fungia fungites</i> (Linnaeus, 1758)			

	82	<i>Fungia granulosa</i> Klunzinger, 1879		X	20R 1U, 3R, 4U, 5R, 6C, 7R, 10R, 12R, 13R, 16R, 18R, 19R, 20R
	83	<i>Fungia gravis</i> Nemenzo, 1955		X	8R,
	84	<i>Fungia horrida</i> Dana, 1846			1R, 2R, 3R, 6R, 11R, 16R, 19R
	85	<i>Fungia klunzingeri</i> Döderlein, 1901			2R, 7U, 10R, 13R, 18R,
	86	<i>Fungia moluccensis</i> Horst, 1919		X	6R, 7R,
	87	<i>Fungia paumotensis</i> Stutchbury, 1833			1U, 2U, 3R, 7U, 8U, 9R, 10R, 11U, 12U, 13R, 14U, 16R, 18U, 19U, 20U
	88	<i>Fungia scruposa</i> Klunzinger, 1816		X	2U, 5U, 10R, 16R, 17U, 18U,
	89	<i>Fungia scutaria</i> Lamarck, 1816		X	1U, 2R, 3U, 6R, 7U, 8U, 9R, 10U, 15R, 16R, 17U, 18U,
21	90	<i>Halomitra pileus</i> (Linnaeus, 1758)		X	2R, 15R, 18R, 19U
	91	<i>Herpolitha limax</i> (Houttuyn, 1772)			1U, 2U, 3U, 5R, 6R, 7R, 8R, 9R, 10R, 11U, 12U, 13U, 15R, 17R, 19U, 20U
	92	<i>Herpolitha weberi</i> Horst, 1921			2R, 3R, 10R, 16U, 17R, 18R, 20R
22	93	<i>Podabacia crustacea</i> (Pallas, 1766)			2R,
	94	<i>Podabacia motuporensis</i> Veron, 1990		X	3R, 4R, 5R, 6R, 7R, 9U, 10R, 11R, 13R, 15R, 17R, 18R, 19R, 20R
		<b>Family Oculinidae</b>			
23	95	<i>Galaxea astreata</i> (Lamarck, 1816)		X	X 2A,3R, 4R, 7A, 8A, 9R, 10R, 11C, 12C, 15C, 16R, 17U, 19R
	96	<i>Galaxea fascicularis</i> (Linnaeus, 1767)			1U, 3R, 4R, 5R, 6R, 8R, 10R, 11R, 12R, 13U, 14R, 17R, 18R, 19U, 20U
		<b>Family Pectinidae</b>			
24	97	<i>Echinophyllia aspera</i> (Ellis & Solander, 1788)		X	8R, 10R, 11R, 14R, 15R, 16R, 17R, 19R
	98	<i>Echinophyllia orpheensis</i> Veron & Pichon, 1980		X	8R, 14R, 18R, 19R, 20R
25	99	<i>Mycedium elephantotus</i> (Pallas, 1766)		X	2R, 3R, 4R, 7R, 8R, 9U, 12R, 13R, 15U, 16U, 18R, 19U
	100	<i>Mycedium robokaki</i> Moll & Borel-Best, 1984	X	X	2R, 9R, 12R, 19R, 20R
26	101	<i>Oxypora lacera</i> Verill, 1864		X	1R, 2U, 3R, 7R, 8R, 9R, 11R, 13R, 15R, 16R, 17U, 18U, 19R, 20R
27	102	<i>Pectinia africana</i> Veron, 2002		X	9R
		<b>Family Mussidae</b>			
28	103	<i>Acanthastrea brevis</i> Milne Edwards & Haime, 1849		X	X



	104	<i>Acanthastrea echinata</i> (Dana, 1846)		X	1U, 2R, 3R, 4R, 7U, 8R, 9U, 11R, 13R, 15R, 16R, 19R, 20R
	105	<i>Acanthastrea hemprichii</i> (Ehrenberg, 1834)			3R, 7R, 9U, 10R, 13R, 14R, 19R
	106	<i>Acanthastrea ishigakiensis</i> Veron, 1990		X	1R, 2R, 3R, 4R, 7R, 8R, 9R, 10R, 12R, 13R, 15U, 16U, 17R, 18U, 19U
	107	<i>Acanthastrea subechinata</i> Veron, 2002	X	X	3R, 16R,
29	108	<i>Blastomussa</i> sp.	X	X	5R, 9U, 16U, 17U
30	109	<i>Cynarina lacrymalis</i> (Milne Edwards & Haime, 1848)		X	Collection
31	110	<i>Lobophyllia hemprichii</i> (Ehrenberg, 1834)			7U, 8U, 10R, 11U, 13R, 14R, 15C, 16C, 19R, 20R
32	111	<i>Scolymia vitiensis</i> Brüggemann, 1877		X	19R
		<b>Family Merulinidae</b>			
33	112	<i>Hydnophora exesa</i> (Pallas, 1766)		X	1U, 2R, 3R, 4R, 5R, 6R, 7U, 8R, 9R, 10R, 11R, 12R, 13R, 14R, 15U, 16U, 17U, 18U, 19U, 20R
	113	<i>Hydnophora microconos</i> (Lamarck, 1816)			3R,
34	114	<i>Merulina ampliata</i> (Ellis & Solander, 1786)		X	2U, 7U, 9U, 10R, 11R, 12R, 13R, 14U, 16R, 18R, 19U, 20R
		<b>Family Faviidae</b>			
35	115	<i>Caulastrea connata</i> (Ortmann, 1892)			12R
36	116	<i>Cyphastrea</i> encrusting			1U, 2R, 3R, 6R, 8R, 9R, 10R, 12R, 16R, 19R, 20R
37	117	<i>Diploastrea heliopora</i> (Lamarck, 1816)		X	1U, 3U, 6R, 7R, 8R, 9R, 10R, 11R, 12R, 13U, 14U, 16R, 17R, 18R, 19R, 20R,
38	118	<i>Echinopora forskaliana</i> (Milne Edwards and Haime, 1850)		X	X
39	119	<i>Favia bestae</i> Veron, 2002	X	X	1C, 2U, 4U, 5C, 6U, 8C, 9U, 10U, 12R, 13R, 14R, 15C, 16C, 17C, 18C, 19R, 20U
	120	<i>Favia matthai</i> Vaughan, 1918			9R
	121	<i>Favia pallida</i> (Dana, 1846)			3R,
	122	<i>Favia rotundata</i> Veron & Pichon, 1977	X	X	19R,
	123	<i>Favia speciosa</i> Dana, 1846			9R, 10R, 17R, 18R,
	124	<i>Favia stelligera</i> (Dana, 1846)			1U, 2U, 3C, 10U, 13U, 14R, 18R, 19R, 20R,
					1U, 3U, 4U, 5R, 7R, 8U, 9R, 10R, 11R, 15U, 16U, 17U, 19R,
	125	<i>Favia truncatus</i> Veron, 2002		X	3R, 13R, 14R, 19R
40	126	<i>Favites abdita</i> (Ellis & Solander, 1786)			10R,
	127	<i>Favites flexuosa</i> (Dana, 1846)			19R
	128	<i>Favites paraflexuosa</i> Veron, 2002		X	1C, 3U, 6R, 7R, 8R, 9R, 10R, 12R, 13R, 14R, 17R,

	129	<i>Favites pentagona</i> Esper, 1794				18R, 19R, 20R
41	130	<i>Goniastrea edwardsi</i> Chevalier, 1971			X	1R, 3U, 6R, 10R, 13R, 14R, 17R, 18R,
	131	<i>Goniastrea favulus</i> (Dana, 1846)	X	X		3U, 4C, 6U, 9U, 11R, 13R, 16R, 17R, 20R
	132	<i>Goniastrea pectinata</i> (Ehrenberg, 1834)			X	3R, 4C, 7R, 9R, 16R,
	133	<i>Goniastrea peresi</i> (Faure & Pichon, 1978)		X	X	1R, 2R, 3R, 4R, 5R, 8R, 10R, 11R, 12R, 13R, 14R,
	134	<i>Goniastrea platygyra</i> -like				16R, 17R, 18R, 19U, 20R
	135	<i>Goniastrea retiformis</i> (Lamarck, 1816)				1U, 2R, 4R, 5R, 7R, 8R, 9R, 10R, 11R, 13R, 14R,
42	136	<i>Leptastrea pruinosa</i> Crossland, 1952				17R, 18R,
	137	<i>Leptastrea purpurea</i> (Dana, 1846) like				19R, 20R
	138	<i>Leptastrea transversa</i> Klunzinger, 1879			X	1U, 16R,
43	139	<i>Leptoria phrygia</i> (Ellis & Solander)			X	6R, 7R, 10R,
44	140	<i>Montastrea curta</i> (Dana, 1846)				3R, 14R, 15R, 16R, 17R,
	141	<i>Montastrea serageldini</i> Veron, 2002	X	X		1C, 3U, 5R, 8R, 9R, 10R, 11R, 13R, 15R, 16R, 17U,
45	142	<i>Oulophyllia bennettiae</i> Veron, Pichon, & Wijsman-Best, 1977		X	X	18U, 19R, 20R
	143	<i>Oulophyllia crispa</i> (Lamarck, 1816)	X	X		1U, 3R, 4R, 8R, 9R, 10R, 13R, 16R, 17R, 19R
46	144	<i>Platygyra acuta</i> Veron, 2002	X	X		1R, 3R, 10R,
	145	<i>Platygyra crosslandi</i> Matthai, 1928	X			3R, 4R, 9U, 13R, 14R
	146	<i>Platygyra daedalea</i> (Ellis & Solander, 1786)				12R,
	147	<i>Platygyra pini</i> Chevalier, 1975				3U, 5R, 8R, 9R, 10R,
47	148	<i>Plesiastrea devantieri</i> Veron, 2002	X			1R, 5R, 6R,
	149	<i>Plesiastrea versipora</i> (Lamarck, 1816)			X	19R
		<b>Family Euphyllidae</b>				1C, 2U, 3R, 4U, 6R, 9C, 10U, 11C, 12C
49	150	<i>Physogyra lichensteinii</i> Milne Edwards & Haime, 1786			X	1C, 4U, 9U,
49	151	<i>Plerogyra sinuosa</i> (Dana, 1846)			X	?10U, 17R, 19R, 20R
		<b>Family Dendrophyllidae</b>				1R, 3R, 5R, 9R, 12R, 13R, 17R
50	152	<i>Tubastraea coccinea</i> Lesson, 1829			X	1U, 2U, 3R, 4U, 6R, 9C, 10U, 11C, 12C, 13U, 14U,
	153	<i>Tubastraea diaphana</i> (Dana, 1846)			X	16R, 19R, 20R
51	154	<i>Turbinaria mesenterina</i> (Lamarck, 1816)			X	1R, 2R, 3R, 4R, 9U, 10R, 11C, 12C, 13R, 14R, 17R,
						19R, 20R
						12R
						Collection
						1U, 3R, 4R, 9U, 10U, 14R, 17U, 18C

	155	<i>Turbinaria peltata</i> (Esper, 1794)			X	8R, 13R, 14R
	156	<i>Turbinaria reniformis</i> Bernard, 1896			X	9U, 10U, 17R, 18R
	157	<i>Turbinaria stellulata</i> (Lamarck, 1816)				4R, 9R, 10R, 11R, 17R
		<b><u>Family Clavulariidae</u></b>				
52	158	<i>Tubipora musica</i> Linnaeus, 1758	X		X	2R, 4R, 8R,
		<b><u>Family Milleporidae</u></b>				
53	159	<i>Millepora dichotoma</i> Forskål, 1775	X	X	X	16U, 17U,
	160	<i>Millepora exaesa</i> Forskål, 1775	X		X	4U, 6U, 7R, 8R, 11R, 16R, 17R, 20R
	161	<i>Millepora foveolata</i> Crossland, 1952	X	X	X	4U, 6U, 7R, 16R,
	162	<i>Millepora intricata</i> Milne-Edwards & Haime, 1857	X	X		15U, 16A,
		<b><u>Family Stylasteridae</u></b>				
54	163	<i>Stylaster</i> sp. <i>l white</i>	X			11U, 12U,
55	164	<i>Distichopora violacea</i> (Pallas, 1766)	X			1U, 6U, 8R, 9R, 11R, 12R, 15R, 17R,

## APPENDIX 2

### Reef Fishes of Andavadoaka, South-western Madagascar

Gerald R. Allen

- A list of fishes was compiled during 21 scuba dives and several hours of snorkelling in the vicinity of Andavadoaka, south-western Madagascar. The survey involved 25 hours of scuba diving and approximately three hours of snorkelling to a maximum depth of 25 m. Additional species were added to the list on the basis of photographs provided by Blue Ventures.
- A total of 385 species belonging to 182 genera and 57 families were recorded during the survey. An extrapolation method utilizing six key index families (Chaetodontidae, Pomacanthidae, Pomacentridae, Labridae, Scaridae, and Acanthuridae) indicates a total fauna for the Andavadoaka region consisting of at least 529 species.
- Wrasses (Labridae), damselfishes (Pomacentridae), and groupers (Serranidae) are the dominant groups at Andavadoaka with 55, 48, and 23 species respectively. Gobies (Gobiidae), usually the most speciose family at most Indo-Pacific localities were represented by only 20 species, but due to their cryptic nature and the small size of many species, they were probably not adequately surveyed.
- Species numbers at visually sampled sites during the survey ranged from 74 to 139, with an average of 105. The latter figure is relatively low and was no doubt influenced by poor underwater visibility which averaged about 5-6 m.
- A total of 66 species recorded during the present survey were not seen during the previous (2002) Conservation International RAP survey of north-western Madagascar, including 20 species that represent new records for Madagascar (Table 1).
- A total of 123 species recorded during the previous CI survey of north-western Madagascar were not seen at Andavadoaka, but most of these records were based on rare sightings of 1-3 individuals or cryptic species collected with rotenone.
- In terms of differences in common species between Andavadoaka and NW Madagascar, *Lutjanus notatus* was abundant at Andavadoaka and rare in the northwest, and conversely *Pomacentrus pavo* was common in the northwest and absent at Andavadoaka. Otherwise, discounting numerous rare species that were seen only at NW Madagascar or around Andavadoaka, the faunas of the two areas are very similar.
- Two species commonly associated with rich coral areas, the cardinalfish *Cheilodipterus artus* and the filefish *Oxymonacanthus longirostris*, which were seen regularly in the northwest, were absent at Andavadoaka, perhaps the result of significant loss of live coral habitat due to recent bleaching events.

- A review of the literature combined with results of the current RAP survey reveal a total reef fish fauna for Madagascar consisting of 815 species.
- In terms of number of species and general faunal composition, Madagascar is similar to other insular localities in the western Indian Ocean including Mauritius, Seychelles, Chagos, and Maldives.
- The majority of Madagascar fishes have broad distributions in the Indo-west and central Pacific. Approximately 20 % of the species range widely over the entire tropical Indian Ocean or are restricted to the western Indian Ocean
- About 30 species are confined to Madagascar and adjacent regions including Mozambique, East Africa, Comoro Islands, St. Brandon's Shoals, and the Mascarene Group
- Eight species are presently known only from the seas of Madagascar. Another four species are known only from Madagascar and the Comoros/Saint Brandon's Shoals.

Table 1 New Reef Fish Species Records for Madagascar recorded at Andavadoaka

Family	Species
Apogonidae	<i>Apogon nigrofasciatus</i>
Apogonidae	<i>Apogon holotaenia</i>
Apogonidae	<i>A. flagelliferus</i>
Blennidae	<i>Ecsenius midas</i>
Gobiidae	<i>Opuia athernoides</i>
Gobiidae	<i>Vanderhorstia ornatissima</i>
Haemulidae	<i>Plectorhinchus vittatus</i>
Haemulidae	<i>Plectorhinchus picus</i> *
Serranidae	<i>Epinephelus tukula</i> *
Caesionidae	<i>Pterocaesio marri</i>
Pempheridae	<i>Pempheris schwenkii</i>
Pomacentridae	<i>Lepidozygus tapeinosoma</i>
Pomacentridae	<i>Chromis agilis</i>
Scynanceiidae	<i>Inimicus filamentosus</i> *
Mullidae	<i>Upeneus pori</i>
Mullidae	<i>Mulloidichthys vanicolensis</i>
Syngnathidae	<i>Corythoichthys punctulatus</i>
Diodontidae	<i>Diodon liturosus</i> *
Tetraodontidae	<i>Canthigaster smithae</i>
Tetraodontidae	<i>Torquigener flavoimaculatus</i> *

\* Identifications from BV Photo Library

Table 2 List of Reef Fish at Andavadoaka

SPECIES	SITE RECORDS
<b>STEGOSTOMATIDAE</b>	
<i>Stegostoma fasciatum</i> (Hermann, 1783)	1
<b>CARCHARHINIDAE</b>	
<i>Galeocerdo cuvieri</i> (Peron & LeSueur, 1822)	1
<i>Triacodon obesus</i> (Rüppell, 1835)	5
<b>SPHYRNIDAE</b>	
<i>Sphyrna lewini</i> (Griffith & Smith, 1834)	1
<b>RHINOBATIDAE</b>	
<i>Rhynchobatus djeddensis</i> (Forsskål, 1775)	9
<b>DASYATIDIDAE</b>	
<i>Dasyatis kuhlii</i> (Müller and Henle, 1841)	6, 8
<i>Taeniura lymma</i> (Forsskål, 1775)	2, 6, 7
<i>T. meyeri</i> (Müller & Henle, 1841)	4
<b>MYLIOBATIDAE</b>	
<i>Aetobatus narinari</i> (Euphrasen, 1790)	4
<b>MURAENIDAE</b>	
<i>Echidna nebulosa</i> (Thünberg, 1789)	1
<i>G. favagineus</i> (Bloch & Schneider, 1801)	5
<i>G. flavimarginatus</i> (Rüppell, 1828)	2, 3
<i>G. javanicus</i> (Bleeker, 1865)*	8
<i>G. undulatus</i> (Lacepède, 1803)	1
<i>Rhinomuraena quaesita</i> Garman, 1888*	5
<i>Siderea grisea</i> (Lacepède, 1803)	1
<i>U. micropterus</i> (Bleeker, 1852)	6
<b>CLUPEIDAE</b>	
<i>H. spilurus</i> (Guichenot, 1863) ?????	3
<i>Spratelloides delicatulus</i> (Bennett, 1832)	9
<b>PLOTOSIDAE</b>	
<i>Plotosus lineatus</i> (Thünberg, 1787)	3, 7
<b>SYNODONTIDAE</b>	
<i>Saurida gracilis</i> (Quoy & Gaimard, 1824)	3, 7, 8
<i>Synodus dermatogenys</i> Fowler, 1912	2, 3, 5, 8, 10, 11
<i>S. jaculum</i> Russell and Cressy, 1979	5
<i>S. variegatus</i> (Lacepède, 1803)	2, 3, 6, 7, 9
<b>BELONIDAE</b>	
<i>Tylosurus crocodilus</i> (Lesueur, 1821)	1
<b>HOLOCENTRIDAE</b>	
<i>Myripristis adusta</i> Bleeker, 1853	2, 4, 7,
<i>M. berndti</i> Jordan & Evermann, 1902	2, 4, 5,
<i>M. botche</i> Cuvier, 1829*	1
<i>M. hexagona</i> (Lacepède, 1802)	7
<i>M. kuntzei</i> Cuvier, 1831	2, 3, 4, 6, 7, 10, 11
<i>M. violacea</i> Bleeker, 1851	2, 3, 4, 7
<i>Neoniphon sammara</i> (Forsskål, 1775)	2, 3, 5, 6, 8, 9, 10, 11
<i>Sargocentron caudimaculatum</i> (Rüppell, 1835)	2, 3, 4, 5, 6, 7, 9, 10
<i>S. diadema</i> (Lacepède, 1802)	2, 3, 8
<i>S. melanospilos</i> (Bleeker, 1858)*	2, 3, 4, 8
<i>S. spiniferum</i> (Forsskål, 1775)	3, 4, 5
<b>AULOSTOMIDAE</b>	

<i>Aulostomus chinensis</i> (Linnaeus, 1766)	2, 3, 4, 6, 8, 9, 10
<b>FISTULARIIDAE</b>	
<i>Fistularia commersoni</i> Rüppell, 1835	6, 12
<b>CENTRISCIDAE</b>	
<i>Aeoliscus punctulatus</i> (Bianconi, 1855)	12
<b>SYNGNATHIDAE</b>	
<i>Corythoichthys punctulatus</i>	12
<i>Doryrhamphus excisus</i>	8, 10
<i>Trachyrhamphus bicourctatus</i> (Bleeker, 1857)	8
<b>SCORPAENIDAE</b>	
<i>Pterois antennata</i> (Bloch, 1787)	4
<i>P. radiata</i> Cuvier, 1829	3
<i>P. miles</i> (Bennett, 1828)	3, 5, 8, 11
<i>S. possi</i> Randall & Eschmeyer, 2001	3, 4
<i>Taenianotus triacanthus</i> Lacepède, 1802	7
<b>SYNANCEIIDAE</b>	
<i>Inimicus filamentousus</i> (Cuvier, 1829)	1
<i>Synanceja verrucosa</i> (Bloch & Schneider, 1801)	3
<b>PLATYCEPHALIDAE</b>	
<i>Papilloculiceps longiceps</i> (Ehrenberg, 1829)	2, 7, 8
<b>SERRANIDAE</b>	
<i>Aethaloperca rogaa</i> (Forsskål, 1775)	5, 6, 7, 9
<i>Anyperodon leucogrammicus</i> (Valenciennes, 1828)	3
<i>Cephalopholis argus</i> Bloch & Schneider, 1801	2, 3, 4, 5, 6, 7, 8, 9, 10, 11
<i>C. boenack</i> (Bloch, 1790)	3, 6, 8, 9, 11
<i>C. leopardus</i>	3
<i>C. miniata</i> (Forsskål, 1775)	5, 7
<i>C. nigripinnis</i> (Valenciennes, 1828)	5
<i>Epinephelus caeruleopunctatus</i> (Bloch, 1790)	7,
<i>E. fasciatus</i> (Forsskål, 1775)	1
<i>E. flavocaeruleus</i> (Lacepède, 1802)	1
<i>E. hexagonatus</i> (Forster, 1801)	2
<i>E. lanceolatus</i> (Bloch, 1790)	1
<i>E. multinotatus</i> (Peters, 1876)	3
<i>E. rivulatus</i> (Valenciennes, 1830)	12
<i>E. spilotoceps</i> Schultz	4
<i>E. tauvina</i> (Forsskål, 1775)	5
<i>E. tukula</i>	1
<i>Grammistes sexlineatus</i> (Thünberg, 1792)	7, 8
<i>Nemanthias carberryi</i> Smith, 1954*	5
<i>Plectropomus laevis</i> (Lacepède, 1802)	1
<i>P. punctatus</i> Quoy & Gaimard, 1824	4, 5
<i>Pseudanthias squamipinnis</i> (Peters, 1855)	3, 5, 6, 7, 9, 10, 11
<i>V. louti</i> (Forsskål, 1775)	2, 4, 5
<b>CIRRHITIDAE</b>	
<i>Cirrhitichthys oxycephalus</i> (Bleeker, 1855)	2, 5, 6, 8, 9, 10, 11
<i>Cirrhitus pinnulatus</i> (Schneider, 1801)	2
<i>Oxycirrhitis typus</i> Bleeker, 1857*	9
<i>Paracirrhites arcatus</i> (Cuvier, 1829)*	5, 9, 10
<i>P. forsteri</i> (Schneider, 1801)	3
<b>PSEUDOCROMIDAE</b>	
<i>Pseudochromis dutoiti</i>	1
<b>PRIACANTHIDAE</b>	
<i>Priacanthus hamrur</i> (Forsskål, 1775)	2, 3, 4, 6, 7, 9, 10, 11

## APOGONIDAE

<i>Apogon angustatus</i> (Smith and Radcliffe, 1911)	5, 7,
<i>A. apogonides</i> (Bleeker, 1856)	11, 12
<i>A. aureus</i> (Lacepède, 1802)	8, 11
<i>A. cooki</i> Macleay, 1881	8, 12
<i>A. cyanosoma</i> (Bleeker, 1853)	3, 7, 8, 11, 12
<i>A. fleureiu</i> (Lacepède, 1802)*	11, 12
<i>A. fraenatus</i> Valenciennes, 1832	9
<i>A. fragilis</i> Smith, 1961	3, 7, 11
<i>A. guamensis</i> Valenciennes, 1832	12
<i>A. kallopterus</i> Bleeker, 1856	3, 11, 12
<i>A. nigrofasciatus</i> Lachner	8
<i>A. holotaenia</i>	8
<i>A. semiornatus</i> Peters, 1876	8
<i>A. flagelliferus</i>	8
<i>Archamia fucata</i> (Cantor, 1850)	3, 6, 7, 11, 12
<i>Cheilodipterus macrodon</i> Lacepède, 1801*	2, 3, 4, 5, 8, 9, 11
<i>C. quinquelineatus</i> Cuvier, 1828	3, 7, 8, 9, 11, 12
<i>Rhabdamia cypselurus</i> Weber, 1909*	11
<i>R. gracilis</i> (Bleeker, 1856)	7
<i>Siphamia mossambica</i> Smith, 1955	3

## CARANGIDAE

<i>Carangoides ferdau</i> (Forsskål, 1775)	12
<i>Caranx heberi</i>	1
<i>C. sexfasciatus</i> Quoy & Gaimard, 1824	5
<i>C. tille</i> Cuvier, 1833	3, 9
<i>Gnathanodon speciosus</i> (Forsskål, 1775)	11
<i>Scomberoides commersonnianus</i> (Lacepède, 1802)	1
<i>Selar crumenophthalmus</i> (Bloch, 1793)	7

## LEIOGNATHIDAE

<i>Gazza minuta</i> (Bloch, 1797)	3
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## LUTJANIDAE

<i>Aphareus furca</i> (Lacepède, 1802)	5
<i>Aprion virescens</i> Valenciennes, 1830	4, 5
<i>Lutjanus bohar</i> (Forsskål, 1775)	4, 5, 6, 7, 11
<i>L. fulviflamma</i> (Forsskål, 1775)	2, 3, 4, 5, 6, 7, 8, 9, 11, 12
<i>L. fulvus</i> (Schneider, 1801)	1,
<i>L. gibbus</i> (Forsskål, 1775)	2, 3, 4, 5, 6, 10
<i>L. kasmira</i> (Forsskål, 1775)	2, 11
<i>L. lutjanus</i> Bloch, 1790	3, 6, 10, 11
<i>L. monostigma</i> (Cuvier, 1828)	5
<i>L. notatus</i> (Cuvier, 1828)	2, 3, 4, 5, 6, 8, 9, 10, 11
<i>Macolor niger</i> (Forsskål, 1775)	2, 3, 4, 5, 6, 7, 8, 9, 10, 11

## CAESIONIDAE

<i>Caesio caerulea</i> Lacepède, 1802	2, 3, 4, 6, 7, 8, 11
<i>C. lunaris</i> Cuvier, 1830	2, 3, 6, 7, 8
<i>C. xanthonota</i> Bleeker, 1853	2, 3, 4, 5, 6, 7, 8
<i>C. sp. 1*</i>	4, 6, 7, 10
<i>Pterocaesio marri</i>	5
<i>P. sp.*</i>	4, 7
<i>P. tile</i> (Cuvier, 1830)	5

## GERREIDAE

<i>Gerres oyena</i> (Forsskål, 1775)	8
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## HAEMULIDAE



<i>Diagramma pictum</i> (Thünberg, 1792)	3, 11
<i>Plectorhinchus flavomaculatus</i>	2, 3, 4, 11
<i>P. gaterinus</i> (Forsskål, 1775)	2, 3, 4, 5, 7, 8, 11
<i>P. picus</i>	1
<i>P. plagiodesmus</i> (Fowler, 1935)	1
<i>P. playfairi</i> (Pellegrin, 1914)	5
<i>P. schotaf</i> (Forsskål, 1775)	2, 3, 4
<i>P. sordidus</i> (Klunzinger, 1870)	3, 8, 10
<i>P. vittatus</i>	7, 12
<b>SPARIDAE</b>	
<i>Acanthopagrus bifasciatus</i> (Forsskål, 1775)	6
<b>LETHRINIDAE</b>	
<i>Gnathodentex aurolineatus</i> Lacepède, 1802	1
<i>Gymnocranius elongatus</i>	3, 9
<i>Lethrinus borbonicus</i> Valenciennes, 1830	2, 3, 4, 6, 7, 9, 10, 11, 12
<i>L. harak</i> (Forsskål, 1775)	3, 7, 8, 11
<i>L. lentjan</i> (Lacepède, 1802)	3, 6, 9, 10, 11, 12
<i>L. mahsena</i> (Forsskål, 1775)	2, 4, 7
<i>L. nebulosus</i> (Forsskål, 1775)	11
<i>L. obsoletus</i> (Forsskål, 1775)	3, 6
<i>L. olivaceus</i> Valenciennes, 1830	10
<i>L. variegatus</i> Valenciennes, 1830	12
<i>L. xanchocheilus</i> Klunzinger, 1870	8
<i>Monotaxis grandoculis</i> (Forsskål, 1775)	2, 3, 4, 5, 6, 7, 9, 10, 11
<b>NEMIPTERIDAE</b>	
<i>Scolopsis bimaculatus</i> Rüppell, 1828	3, 6, 8, 9, 10, 11
<i>S. gahnam</i> (Forsskål, 1775)	2, 3, 5, 6, 8, 10, 11
<i>S. vosmeri</i> (Bloch, 1792)	9
<b>MULLIDAE</b>	
<i>Mulloidichthys vanicolensis</i>	2, 10, 11
<i>Parupeneus barberinus</i> (Lacepède, 1801)	5, 6, 7, 8, 9, 10, 11, 12
<i>P. bifasciatus</i> (Lacepède, 1801)	7
<i>P. cyclostomus</i> (Lacepède, 1802)	2, 4, 5, 6, 8, 10
<i>P. heptacanthus</i> (Lacepède, 1801)	3, 6, 7, 9
<i>P. indicus</i> (Shaw, 1803)	2
<i>P. macronema</i> (Lacepède, 1801)	2, 3, 4, 5, 6, 7, 8, 9, 10, 11
<i>P. pleurostigma</i> (Bennett, 1830)	2, 5, 6
<i>P. rubescens</i> (Lacepède, 1801)	2, 7, 12
<i>Upeneus pori</i>	3
<b>PEMPHERIDAE</b>	
<i>Parapriacanthus ransonneti</i> Steindachner, 1870	7, 11
<i>Pempheris oualensis</i> Cuvier, 1831	1, 11
<i>Pempheris schwenkii</i>	3, 6, 8, 11
<i>P. vanicolensis</i> Cuvier, 1831	2, 3, 4, 6, 7
<b>MONODACTYLIDAE</b>	
<i>Monodactylus argenteus</i> (Linnaeus, 1758)	1
<b>CHAETODONTIDAE</b>	
<i>Chaetodon auriga</i> Forsskål, 1775	2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12
<i>C. blackburni</i> Desjardins, 1836	6, 8, 9
<i>C. falcula</i> Bloch, 1793	3, 6, 8, 9, 11
<i>C. guttatissimus</i> Bennett, 1823	2, 3, 4, 5, 6, 7, 8, 9, 10, 11
<i>C. interruptus</i> Ahl, 1923	4, 5, 9, 10
<i>C. kleinii</i> Bloch, 1790	3, 4, 5, 6, 9, 10, 11
<i>C. lunula</i> Lacepède, 1803	3, 5, 6, 7, 9, 10, 11

<i>C. madagaskariensis</i> Ahl, 1923	2, 3, 4, 5, 6, 7, 8, 9, 10, 11
<i>C. melanotus</i> Schneider, 1801	3
<i>C. meyeri</i> Schneider, 1801	2, 6, 9, 10
<i>C. trifascialis</i> Quoy and Gaimard, 1824	6, 9, 10
<i>C. trifasciatus</i> Park, 1797	2, 3, 4, 6, 7,
<i>C. vagabundus</i> Linnaeus, 1758	2, 3, 4, 6, 7, 8, 9, 10
<i>C. xanthocephalus</i> Bennett, 1832	6, 9, 10
<i>C. zanzibarensis</i> Playfair, 1867	5, 10
<i>Forcipiger flavissimus</i> Jordan & McGregor, 1898	2, 4, 5, 7, 9, 10
<i>F. longirostris</i>	1
<i>Hemitaurichthys zoster</i> (Bennett, 1831)	2
<i>Heniochus acuminatus</i> (Linnaeus, 1758)	2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12
<i>H. diphreutes</i>	5
<i>H. monoceros</i> Cuvier, 1831	3, 5, 6, 7, 8, 10
<b>POMACANTHIDAE</b>	
<i>Apolemichthys trimaculatus</i> (Lacepède, 1831)	2, 5, 6, 7, 9, 10
<i>Centropyge acanthops</i> (Norman, 1922)	1
<i>C. bispinosa</i> (Günther, 1860)	4
<i>C. multispinis</i> (Playfair, 1867)	2, 3, 4, 5, 6, 7, 8, 9, 10, 11
<i>Pomacanthus chrysurus</i> Cuvier, 1831	2, 3, 4, 5, 6,
<i>P. imperator</i> (Bloch, 1787)	2, 4, 5
<i>P. semicirculatus</i> Cuvier, 1831	2, 4, 5, 6, 7, 8, 9, 10
<i>Pygoplites diacanthus</i> (Boddaert, 1772)	2, 4, 5, 6, 7, 10
<b>POMACENTRIDAE</b>	
<i>Abudefduf notatus</i>	1
<i>A. septemfasciatus</i> (Cuvier, 1830)	13
<i>A. sexfasciatus</i> Lacepède, 1802	3, 7, 8, 12
<i>A. sordidus</i> (Forsskål, 1775)	13
<i>A. sparoides</i> (Cuvier, 1830)	2, 3, 4, 6, 7, 8, 9, 10, 12
<i>A. vaigiensis</i> (Quoy and Gaimard, 1825)	6, 12
<i>Amblyglyphidodon indicus</i> (Allen & Randall, 2002)	2, 3, 4, 5, 6, 7, 8, 9, 10, 11
<i>Amphiprion akallopis</i> (Bleeker, 1853)	2, 3, 6, 7, 8, 9, 10, 11
<i>A. latifasciatus</i> Allen, 1972	4, 6, 7, 8, 9, 10, 11
<i>Chromis agilis</i> Smith ?	3, 7
<i>C. atripectoralis</i> Welander & Schultz, 1951*	3
<i>C. dimidiata</i> (Klunzinger, 1871)	2, 3, 4, 5, 6, 7, 8, 9, 10, 11
<i>C. lepidolepis</i> Bleeker, 1877	2, 4, 5, 6, 7, 8, 10, 11
<i>C. nigrura</i> Smith, 1960	2, 3, 5, 6, 7, 9, 10
<i>C. opercularis</i> (Günther, 1867)	2, 3, 4, 5, 6, 7, 8, 9, 10, 11
<i>C. ternatensis</i> (Bleeker, 1856)	2, 3, 4, 5, 6, 7, 8, 9, 10, 11
<i>C. viridis</i> (Cuvier, 1830)	3, 7
<i>C. weberi</i> Fowler & Bean, 1928	2, 4, 5, 6, 7, 8, 10, 11
<i>Chrysiptera annulata</i> (Peters, 1855)	8, 12
<i>C. brownriggii</i> (Bennett, 1828)	13
<i>C. sp.</i>	1
<i>Dascyllus aruanus</i> (Linnaeus, 1758)	3
<i>D. carneus</i> Fischer, 1885	6, 11
<i>D. trimaculatus</i> (Rüppell, 1928)	2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12
<i>Lepidozygus tapeinosoma</i>	5
<i>Neoglyphidodon melas</i> (Cuvier, 1830)	2, 4, 7, 10, 11
<i>Neopomacentrus azysron</i> (Bleeker, 1877)	3, 8, 9, 11
<i>N. cyanomos</i> (Bleeker, 1856)	11
<i>Plectroglyphidodon dickii</i> (Liénard, 1839)	3, 6, 9, 10
<i>P. johnstonianus</i> Fowler & Ball, 1924*	10

<i>P. lacrymatus</i> (Quoy and Gaimard, 1824)	2, 3, 4, 7, 8, 9, 10, 11
<i>P. leucozonus</i> (Bleeker, 1859)	13
<i>Pomacentrus aquilus</i> Allen & Randall, 1980	3, 8, 11, 12
<i>P. baenschii</i> Allen, 1991*	2, 3, 4, 6, 7, 8, 9, 10, 11, 12
<i>P. caeruleus</i> Quoy & Gaimard, 1825	2, 3, 4, 6, 8, 10, 11
<i>P. caeruleopunctatus</i> Allen, 2002*	3
<i>P. sulfureus</i> Klunzinger, 1871	2, 3, 8, 11
<i>P. trichorus</i> (Günther, 1867)	2, 3, 4, 6, 7, 8, 9, 11
<i>P. trilineatus</i> Cuvier, 1830	3, 7, 8, 9, 11
<i>Stegastes fasciolatus</i> (Ogilby, 1889)	7
<b>LABRIDAE</b>	
<i>Anampses caeruleopunctatus</i> Rüppell, 1828	2, 4, 6, 7
<i>A. lineatus</i> Randall, 1972*	2, 5, 7, 8
<i>A. meleagrides</i> Valenciennes, 1840	2, 4, 5, 6, 7, 8
<i>A. twistii</i> Bleeker, 1856	2, 3, 4, 5, 6, 7, 8, 9, 10, 11
<i>Bodianus anthioides</i> (Bennett, 1831)	2, 4, 6, 7, 9, 10
<i>B. axillaris</i> (Bennett, 1831)	2, 3, 4, 5, 6, 7, 8, 9, 11
<i>B. bilunulatus</i> Lacepède, 1801)	1
<i>B. diana</i> (Lacepède, 1801)	5
<i>Cheilinus chlorurus</i> (Bloch, 1791)	3, 4
<i>C. fasciatus</i> (Bloch, 1791)	3, 4
<i>C. oxycephalus</i> (Bleeker, 1853)	2, 3, 4, 6, 7, 8, 11
<i>C. trilobatus</i> Lacepède, 1802	2, 3, 4, 6, 7, 8, 9, 11
<i>C. undulatus</i> Rüppell, 1835	1
<i>Cheilio inermis</i> (Forsskal, 1775)	12
<i>Cirrhitilabrus exsquisitus</i> Smith, 1957*	3, 5
<i>Coris caudimacula</i> (Quoy & Gaimard, 1834)	2, 4, 5, 6, 7, 8, 11
<i>C. cuvieri</i> (Bennett, 1831)	2, 4, 5, 7
<i>Epibulus insidiator</i> (Pallas, 1770)	2, 3, 4, 5, 6, 7, 8, 9, 10, 11
<i>Gomphosus caeruleus</i> Lacepède, 1801	2, 3, 4, 5, 6, 7, 8, 9, 10, 11
<i>Halichoeres cosmetus</i> Randall & Smith, 1982*	2, 4, 5
<i>H. dussumieri</i> (Valenciennes, 1839)	8
<i>H. hortulanus</i> (Lacepède, 1802)	2, 4, 5, 6, 7, 8, 9, 10, 11
<i>H. marginatus</i> Rüppell, 1835	2, 3
<i>H. nebulosus</i> (Valenciennes, 1839)	7, 8
<i>H. scapularis</i> (Bennett, 1832)	3, 11
<i>Hemigymnus fasciatus</i> (Bloch, 1792)	2, 3, 4, 6, 7, 8, 9, 10, 11
<i>H. melapterus</i> (Bloch, 1791)	2, 3, 4, 6, 7, 8, 10
<i>Hologymnosus annulatus</i> (Lacepède, 1801)	2, 3, 4, 6, 7, 8, 10
<i>H. doliatus</i> (Lacepède, 1801)*	10
<i>Labrichthys unilineatus</i> (Guichenot, 1847)	3
<i>Labroides bicolor</i> Fowler & Bean, 1928	2, 3, 4, 5, 6, 7, 9, 10, 11
<i>L. dimidiatus</i> (Valenciennes, 1839)	2, 3, 4, 5, 6, 7, 8, 9, 10, 11
<i>Labropsis xanthonota</i> Randall, 1981	5
<i>Macropharyngodon bipartitus</i> Smith, 1957	4, 11
<i>M. cyanoguttatus</i> Randall, 1978*	2, 3, 4, 7, 8, 10
<i>M. vivianae</i> Randall, 1978	4
<i>Novaculichthys macrolepidotus</i> (Bloch, 1791)	12
<i>N. taeniourus</i> (Lacepède, 1802)	2
<i>Oxycheilinus bimaculatus</i> (Valenciennes, 1840)	3, 7, 8, 11
<i>O. diagrammus</i> (Lacepède, 1802)	3, 4, 5, 6, 7, 8, 9, 10, 11
<i>O. mentalis</i> (Rüppell, 1828)	3
<i>Pseudocheilinus evanidus</i> Jordan & Evermann, 1902	2, 3, 5, 6
<i>P. hexataenia</i> (Bleeker, 1857)	2, 3, 4, 5, 6, 8, 9, 10, 11

<i>Pseudocoris</i> sp.*	5
<i>Pseudodax moluccanus</i> (Valenciennes, 1840)	2, 4, 5, 7, 10
<i>Pteragogus pelycus</i> Randall, 1981	3, 8
<i>Stethojulis albovittata</i> (Bonnaterre, 1785)	3, 4, 5, 6, 7
<i>S. bandanensis</i>	10
<i>S. interrupta</i> (Bleeker, 1851)	8
<i>S. strigiventer</i> (Bennett, 1832)	3, 4, 9, 11, 12
<i>Thalassoma amblycephalum</i> (Bleeker, 1856)	3, 5, 6, 7, 8, 10
<i>T. hardwicke</i> (Bennett, 1828)	3, 7, 8, 11
<i>T. hebraicum</i> (Lacepède, 1801)	2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12
<i>T. lunare</i> (Linnaeus, 1758)	2, 3, 4, 5, 6, 7, 8, 9, 10, 11
<i>T. purpureum</i> (Forsskål, 1775)	7
<b>SCARIDAE</b>	
<i>Calotomus carolinus</i> (Valenciennes, 1839)	2, 4, 7, 10
<i>Cetoscarus bicolor</i> (Rüppell, 1828)	2, 3, 7, 8
<i>Chlorurus atrilunula</i> Randall & Bruce, 1983*	2, 3, 4, 5, 6, 7, 8, 10, 11
<i>C. cyanescens</i> (Valenciennes, 1840)	2, 4, 6, 7, 8, 11
<i>C. sordidus</i> (Forsskål, 1775)	2, 3, 4, 5, 6, 7, 8, 9, 10, 11
<i>Hipposcarus harid</i> (Forsskål, 1775)	1
<i>Leptoscarus vaigiensis</i> (Quoy & Gaimard, 1824)	12
<i>Scarus caudofasciatus</i> (Günther, 1862)	2, 4
<i>S. frenatus</i> Lacepède, 1802	2, 6, 7, 8
<i>S. ghobban</i> Forsskål, 1775	3, 5, 6, 7, 8, 9, 11
<i>S. niger</i> Forsskål, 1775	2, 3, 4, 6, 7, 8, 9, 10
<i>S. psittacus</i> Forsskål, 1775	7, 11
<i>S. rubroviolaceus</i> Bleeker, 1849	2, 5, 6, 7, 9, 10
<i>S. russelli</i> Valenciennes, 1840*	5, 6, 7, 9
<i>S. scaber</i> Valenciennes, 1840	1
<i>S. tricolor</i> Bleeker, 1849	9, 10
<i>S. viridifurcatus</i> (Smith, 1956)*	6, 7, 9, 10
<b>PINGUIPEDIDAE</b>	
<i>Parapercis hexophthalma</i> (Cuvier, 1829)	2, 3, 4, 6, 7, 8, 9, 10, 11
<b>BLENNIIDAE</b>	
<i>Aspidontus taeniatus tractus</i> Fowler, 1903	7
<i>Blenniella periophthalmus</i> (Valenciennes, 1836)	13
<i>Cirrhipetes stigmaticus</i> Strasburg & Schultz, 1953	3, 4
<i>Ecsenius midas</i>	11
<i>E. nalolo</i> Smith, 1959*	7, 9
<i>Exallias brevis</i> (Kner, 1868)	10
<i>Istiblennius edentulus</i> Bloch & Schneider, 1801	12
<i>Meiacanthus mossambicus</i> Smith, 1959	3, 4, 6, 7, 8, 11
<i>Plagiotremus rhinorhynchus</i> (Bleeker, 1852)	2, 3, 4, 5, 6, 7, 8, 9, 10, 11
<i>P. tapeinosoma</i> (Bleeker, 1857)	3, 8, 10
<i>Petroscirtes breviceps</i> (Valenciennes, 1836)	12
<i>Salarias fasciatus</i> (Bloch, 1786)	12
<b>CALLIONYMIDAE</b>	
<i>Callionymus delicatulus</i> Smith, 1963	3
<b>GOBIIDAE</b>	
<i>Amblyeleotris periophthalma</i> (Bleeker, 1853)	8
<i>A. steinitzi</i> (Klausewitz, 1974)	7
<i>A. wheeleri</i> (Polunin & Lubbock, 1977)	4, 6, 7, 8
<i>Amblygobius albimaculatus</i> (Rüppell, 1830)	3, 11
<i>A. tekumaji</i> Smith, 1959	3
<i>Bathygobius albopunctatus</i> (Valenciennes, 1837)	12

<i>Cryptocentrus cryptocentrus</i> (Valenciennes)	3
<i>C. strigilliceps</i> (Jordan & Seale, 1906)	3, 7, 8, 11, 12
<i>Ctenogobius crocineus</i> Smith, 1959	3, 7, 11
<i>Eviota nebulosa</i> Smith, 1958	2
<i>Fusigobius duospilus</i> Hoesé & Reader, 1985*	3
<i>Gnatholepis anjerensis</i> (Bleeker, 1851)	3, 12
<i>G. cauerensis</i> Bleeker, 1853	2, 3, 6, 7, 8, 9, 11
<i>Istigobius decoratus</i> (Herre, 1927)	2, 3, 4, 7, 8, 11
<i>Macrodontogobius wilburi</i> Herre, 1936*	11
<i>Opua athernoides</i>	3, 11
<i>Oplopomus oplopomus</i> (Valenciennes, 1837)	1
<i>Valenciennea puellaris</i> (Tomiyama, 1936)	3, 7, 11
<i>V. strigata</i> (Broussonet, 1782)	4, 5, 6
<i>Vanderhorstia ornatissima</i> Smith, 1959	3, 7, 11
<b>MICRODESMIDAE</b>	
<i>Gunnelichthys curiosus</i> Dawson, 1968*	3, 8, 11
<b>PTERELEOTRIDAE</b>	
<i>Nemateleotris magnifica</i> Fowler, 1938	2, 4, 5, 6, 9, 10
<i>Ptereleotris evides</i> (Jordan & Hubbs, 1925)	2, 4, 6, 7, 8, 9, 10
<b>EPHIPPIDAE</b>	
<i>Platax teira</i> (Forsskål, 1775)	1
<b>SIGANIDAE</b>	
<i>Siganus argenteus</i> (Quoy & Gaimard, 1824)	2, 3, 4, 6, 7, 9, 10
<i>S. luridus</i> (Rüppell, 1829)	2, 4, 6, 7, 9, 10
<i>S. stellatus</i> (Forsskål, 1775)	2, 7, 9, 10
<i>S. sutor</i> (Valenciennes, 1835)	12
<b>ZANCLIDAE</b>	
<i>Zanclus cornutus</i> Linnaeus, 1758	2, 3, 4, 5, 6, 7, 8, 9, 10, 11
<b>ACANTHURIDAE</b>	
<i>Acanthurus dussumieri</i> Valenciennes, 1835	2, 3, 4, 5, 6, 7, 10, 11
<i>A. leucosternon</i> Bennett, 1832	2, 4
<i>A. lineatus</i> (Linnaeus, 1758)	7, 10
<i>A. mata</i> (Cuvier, 1829)	2, 5, 6, 10
<i>A. nigricaudus</i> Duncker & Mohr, 1929	2, 3, 4, 6, 7, 8, 9, 10, 11
<i>A. nigrofuscus</i> (Forsskål, 1775)	2, 3, 4, 5, 6, 7, 8, 9, 10, 11
<i>A. tennenti</i> Günther, 1861	2, 4, 5, 10
<i>A. thompsoni</i> (Fowler, 1923)*	5, 8
<i>A. triostegus</i> (Linnaeus, 1758)	3, 4, 7, 8, 11
<i>A. xanthopterus</i> Valenciennes, 1835	11
<i>Ctenochaetus binotatus</i> Randall, 1955*	2, 3, 4, 5, 6, 7, 9, 10, 11
<i>C. striatus</i> (Quoy & Gaimard, 1824)	2, 3, 4, 5, 6, 7, 8, 9, 10, 11
<i>C. truncatus</i> Randall & Clements, 2001*	2, 3, 4, 5, 6, 7, 9, 10, 11
<i>Naso brachycentron</i> (Valenciennes, 1835)	2, 4
<i>N. brevirostris</i> (Valenciennes, 1835)	4, 5, 6, 7, 9
<i>N. caeruleacauda</i> Randall, 1994*	2, 5, 7, 8
<i>N. elegans</i> Rüppell, 1829	2, 4, 5, 6, 7, 9, 10, 11
<i>N. hexacanthus</i> (Bleeker, 1855)*	5
<i>N. unicoloris</i> (Forsskål, 1775)	3, 5, 7
<i>N. vlamingii</i> (Valenciennes, 1835)	2, 4, 5, 7, 10
<i>Zebrasoma desjardini</i> (Bennett, 1836)	2, 3, 4, 5, 6, 7, 10, 11
<i>Z. scopas</i> (Cuvier, 1829)	2, 3, 4, 5, 6, 7, 8, 9, 10, 11
<b>SPHYRAENIDAE</b>	
<i>Sphyræna barracuda</i> (Walbaum, 1792)	1
<i>S. flavicauda</i> Rüppell, 1838	2, 3, 11

<i>S. genie</i> Klunzinger, 1870	5
<b>BOTHIDAE</b>	
<i>B. pantherinus</i> (Rüppell, 1830)	3
<b>BALISTIDAE</b>	
<i>Abalistes stellatus</i> (Lacepède, 1798)	8
<i>Balistapus undulatus</i> (Park, 1797)	2, 3, 4, 5, 6, 7, 9, 11
<i>Balistoides conspicillum</i> (Bloch & Schneider, 1801)	4, 5, 7, 9, 10
<i>B. viridescens</i> (Bloch & Schneider, 1801)	2, 3, 4, 5, 6, 7
<i>Melichthys indicus</i> Randall & Klausewitz, 1973	2, 4, 5
<i>Odonus niger</i> (Rüppell, 1836)	5
<i>Pseudobalistes fuscus</i> (Bloch & Schneider, 1801)	8
<i>Rhinecanthus aculeatus</i> (Linnaeus, 1758)	1
<i>Rhinecanthus rectangulus</i> (Bloch & Schneider, 1801)	8
<i>Sufflamen bursa</i> (Bloch & Schneider, 1801)	2, 4, 5, 6, 7
<i>S. chrysoptera</i> (Bloch & Schneider, 1801)	2, 4, 5, 6, 7, 8, 9, 10, 11
<i>S. fraenatus</i> (Latreille, 1804)	6
<b>MONACANTHIDAE</b>	
<i>Amanes scopas</i> (Cuvier, 1829)	2, 9, 10
<i>Cantherines dumerilii</i> (Hollard, 1854)*	2
<i>C. pardalis</i> (Rüppell, 1837)	4, 5, 6, 7, 9, 10
<i>Paraluteres prionurus</i> (Bleeker, 1851)*	4, 6, 7
<i>Pervagor janthinosoma</i> (Bleeker, 1854)	2
<b>OSTRACIIDAE</b>	
<i>Lactoria cornuta</i> (Linnaeus, 1758)	1, 2
<i>Ostracion cubicus</i> Linnaeus, 1758	2
<i>O. meleagris</i> Shaw, 1796	2, 3, 4, 7, 8, 10, 11
<b>TETRAODONTIDAE</b>	
<i>Arothron hispidus</i> (Linnaeus, 1758)	6, 7
<i>A. immaculatus</i> (Bloch & Schneider, 1801)	1
<i>A. nigropunctatus</i> (Bloch & Schneider, 1801)	2, 4, 5, 7
<i>A. stellatus</i> (Schneider, 1801)	1
<i>Canthigaster bennetti</i> (Bleeker, 1854)	2, 3, 4, 7, 8, 11
<i>C. janthinoptera</i> (Bleeker, 1855)	2, 4
<i>C. smithae</i> Allen & Randall	4
<i>C. solandri</i> (Richardson, 1844)	2, 3, 4, 5, 6, 7, 8, 9, 10, 11
<i>C. valentini</i> (Bleeker, 1853)	2, 3, 4, 5, 6, 7, 8, 9, 10, 11
<i>Torquigener flavomaculatus</i>	1
<b>DIODONTIDAE</b>	
<i>Diodon liturosus</i>	1
<i>Diodon hystrix</i> Linnaeus, 1758	3

#### Site Records:

1 = BV Photo Library, 2 = Shark Alley, 3 = Coco Beach, 4 = Nosy Fasy, 5 = Andravamaiki, 6 = THB, 7 = Valleys, 8 = Andavadoaka Rock, 9 = 007, 10 = Recruitment, 11 = Half Moon, 12 = Andavadoaka Lagoon (snorkel in seagrass bed), 13 = Laguna Blu (snorkel opposite resort).

## APPENDIX 3

### TAXONOMIC EVALUATION OF THE MARINE BIODIVERSITY AT ANDAVADOAKA MADAGASCAR: MOLLUSCS

November 2005

Mission Report for the Wildlife Conservation Society Marine Program, Madagascar and the Direction de la Préservation de la Biodiversité, Ministère de l'Environnement, des Eaux et Forêts, Madagascar (organisation of tutelage: Institut Halieutique et des Sciences Marines, IHSM)

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#### 1) Methodology

The mission took place from the 25th to the 29th of november 2005 in Andavadoaka, along the coastline (between Antseranambe Point to the South and Andavadoaka Bay to the North), on the perimeter of the islands of Nosy Hao and Nosy Fasy, and on marine sites referenced by the NGO Blue Ventures.

Excursions by foot throughout the tidal zone and the mangroves were used to record the number of live mollusc species found in these areas, and the recently-deposited shells on the shore were recorded to give an estimate of the species found at depth. A methodology for a survey on the specific biodiversity of marine molluscs found in the intertidal zone was presented to the NGO Blue Ventures.

Several snorkelling transects were carried out in front of Andavadoaka Point, in the bay to the North of Antseranambe Point, and all around the islands of Nosy Hao and Nosy Fasy (R1, R2,etc.)

Several SCUBA-diving excursions were carried out on dive sites referenced by the NGO Blue Ventures (BV sites).

Micro-molluscs were not dealt with, nor were species living within the coral, to avoid destruction of coral colonies. On all surveys the species were identified, recorded and photographed; certain specimens were collected in order to further their identification and to photograph them in better conditions before being released (new 'no kill' methodology elaborated by ARVAM (Alain BARRERE and Jean Pascal QUOD, 2004), which allows the completion of the collection whilst preserving as much as possible the organisms). For each species, the abundance was recorded (+ : present , ++ several individuals, +++ : very abundant and ++++ : dominant).



in situ : *Conus augur*



in situ : *Notodoris minor*



collection : *Cypraea isabella*



collection : *Codakia tigrina*

Photographs : Al. Barrère

### Survey Plan :

Date	Stations	Depth	Type of Habitat
25/11/05	R1 Nosy Hao SE	0-5 m	Seagrass, algal reef flats
	R2 Nosy Hao SE	0-5 m	Seagrass, algal reef flats
	R3 Nosy Hao SE	0-5 m	Seagrass, algal reef flats
	Site BV1 (Betramosy)	32 m	External reef slope
	R4 Split Rock S	0-5 m	Detritic reef flat
26/11/05	R1 Nosy Hao N	0-5 m	Seagrass, algal reef flats
	R2 Nosy Hao N	0-5 m	Seagrass, algal reef flats
	R3 Nosy Hao N	0-5 m	Seagrass, algal reef flats
	SiteBV2 (Ambatobe)	20 m	External reef slope
27/11/05	R1 Nosy Fasy E	0-5 m	Seagrass, algal reef flats
	R2 Nosy Fasy S	0-5 m	Seagrass, algal reef flats
	R3 Nosy Fasy N	0-5 m	Seagrass, algal reef flats
	R4 Dive Nosy Fasy W	0-20 m	External reef slope
	R5 Andavadoaka - Antseranambe Bay	0-5 m	Sedimentary lagoon
	R6 Split Rock S cf R4	0-5 m	Detritic reef flat
28/11/05	R1 Nosy Hao S	0-5 m	Seagrass, algal reef flats
	Site BV3 (Andrivamaïke)	30 m	External reef slope
29/11/05	Site BV4 Nosy Hao SW	30 m	External reef slope
	R2 Nosy Hao S	0-5 m	Seagrass, algal reef flats

19 marine sites were studied, 14 by snorkelling transects (90 to 120m per transect) and 5 SCUBA-dives to a maximum depth of 32m (average dive time of 40mn).

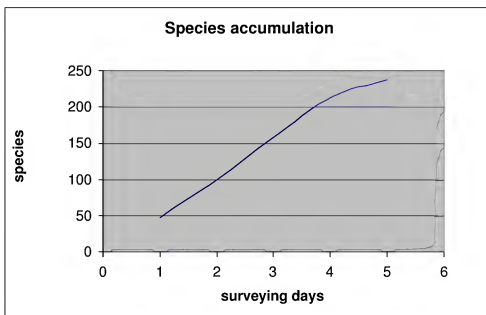




The previous figure (J.B. Nicet, ARVAM) shows the location of the snorkelling and dive transects carried out during this mission. All points on the photograph are georeferenced by Mapinfo from GPS coordinates, the 3 points underneath corresponding to dives have been placed approximatively (due to the distance separating them from the other sites they would have decreased the legibility of this document).

#### Evolution of the number of species found throughout the mission

Days	Number of species	Number of cumulative species
1	48	48
2	52	100
3	58	158
4	55	213
5	25	238



## 2) Results / Discussion

- 71 families, 112 genera, 238 species were found in the 5 days of surveying.
- The short duration of this mission allowed only a partial look at the molluscan fauna of Andavadoaka, but by extrapolating the results obtained, the number of species found in 15 surveying days would be of the order of 450-500 species, which correlates well with the results from previous missions:
  - 525 species found during the RAP mission of January 2002 (16 surveying days) in North-West Madagascar, Fred E. Wells (CI Marine RAP survey)
  - 294 species found during the Hibernia reef mission of 1993 (6 surveying days) by Willan (Western Australian Museum Survey)
  - 260 species found during the Rowley Shoals mission of 1986 (7 surveying days) Wells and Slack-Smith (Western Australian Museum Survey)
- The results are coherent with those obtained on the last mission in the North-West of Madagascar: RAP marine mission of January 2002, Fred E. Wells (CI Marine RAP survey)

Taxonomic composition of the Molluscs found in Andavadoaka

Class	Families	Genera	Species
<b>Gastropoda</b>	39	62	171
<b>Opisthobranchia (sub-class)</b>	7	11	15
<b>Polyplacophora</b>	1	1	1
<b>Bivalvia</b>	21	35	47
<b>Cephalopoda</b>	3	3	4
<b>Total</b>	<b>71</b>	<b>112</b>	<b>238</b>

Table comparing the relative quantity of species within the most well represented families:

Families	North-west Madagascar January 2002 Fred E. Wells	Andavadoaka November 2005 A. Barrère
Trochidae	1,7%	2,5%
Turbinidae	1%	2,5%
Neritidae	0,8%	1,7%
Cerithiidae	3,6%	3%
Strombidae	2,6%	4,6%
Cypraeidae	6%	11,3%
Naticidae	2%	2%
Cassidae	0,4%	1,7%
Cymatiidae	1,8%	2%
Muricidae	6%	2%
Buccinidae	2%	1,3%
Nassariidae	2%	1,7%
Fasciolaridae	2%	2%
Olividae	2,2%	1,7%
Mitridae	2%	3,4%
Costellariidae	4,5%	1,7%
Conidae	9%	12,6%
Terebridae	4,7%	2,5%
Chromodorididae	1,8%	2%
Phyllidiidae	1,5%	1,3%
Arcidae	1,3%	1,7%
Mytilidae	0,8%	2%
Pinnidae	0,8%	1,3%
Pteriidae	0,6%	1,3%
Pectinidae	4,5%	1,3%
Ostreidae	0,4%	0,8%
Lucinidae	0,6%	1,3%
Cardiidae	2,6%	1,7%
Tellinidae	2,5%	2%
Veneridae	3,8%	2%

The Conidae, Cypraeidae, Strombidae, Cerithiidae, Mitridae were the dominant families in terms of number of species present.

The area studied was rich in molluscs, the results show a high diversity, close to that found in the North-West of Madagascar. This may be due to the diversity of biotopes (sedimentary bay, isolated cay, biodetritic and coralline reef flat), the drop in ichthyologic predation (overfishing), and to the weak anthropogenic pressure exerted on deep marine sites (little SCUBA activity in the area). It should be noted that no Bursidae or Turridae were seen throughout this mission.

- The species distribution depends on the type of habitat: algal reef flats ; seagrass beds ; detritic reef flats ; external reef slop ; sedimentary lagoon :
  - Surrounding the islands of Nosy Hao and Nosy Fasy, the habitat is essentially algal-seagrass reef flat: the dominant species is *Cypraea annulus* (up to 50 individuals/m<sup>2</sup>), other species are abundant : *Cerithium nodulosum*, *Tridacna sp* as well as some Strombrids and Vasids. The density of *Tridacna sp*, in certain areas (transects around Nosy Hao) is of the order of 10 individuals per 100 m<sup>2</sup>. This species is protected (CITES and UNEP-WCMC lists), of high commercial interest and its abundance is remarkable: this site must be protected.
  - On the detritic reef flat zones, few molluscs were found, mostly Trochids and Turbinids.
  - The habitats on the outer reef slope make for a benthic fauna rich in hydrozoans, alcyonians and ascidians. The diversity of gastropods and bivalves is normal for this type of environment, however it should be noted that a relatively high abundance and diversity of opisthobranch nudibranchs was present (between 5 and 10 individuals found on each dive, with on average 4 different per dive).
  - In the sedimentary lagoon (the bay between Andavadoaka and Antseranambe Point), the dominant species were *Anadara antiquata* and *Terebralia palustris* (within the mangrove), other species are abundant : *Donax sp*, *Terebra felina* and in places *Atrina vexillum*.
  - Within the intertidal zone, on the rocks and within the tide pools, the main species are *Nerita plicata* , *Clypeomorus batillariaeformis* and *Saccostrea cucullata*.
- The highest biomass was found on the transects carried out in the perimeter of the islands of Nosy Hao and Nosy Fasy, due to a high abundance of *Octopus cyanea* and *Tridacna sp*. (especially surrounding Nosy Hao for the latter species) and a high abundance of bivalves within the sedimentary lagoon (*Anadara sp*, *Donax sp*).

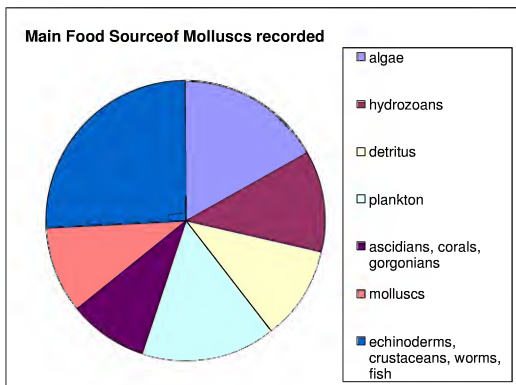
### 3) Trophic Guilds

The distribution of main sources of food divides the molluscan fauna into 3 main trophic guilds:

- Phytoplanktivores, particularly in the algal zones surrounding the isolated islands;
- Detritivores and filter feeders, particularly in the transport and sedimentation zones (back of the bay)
- Carnivores (predation) and benthic detritivores throughout the different zones.

It is worth noting the richness in predatory species.

Main food source	No. of Species
algae	50
hydrozoans	34
detritus	32
plankton	46
ascidians, corals, gorgonians	27
molluscs	30
echinoderms, crustaceans, worms, fish	76



#### 4) Perspectives

The main issue facing the molluscs in the study zone is the octopus fishery, which needs to sustain the local Vezo population whilst preserving the stock of *Octopus cyanea*. Trial no-take-zones (NTZ's) with a regular re-opening are currently in place around the islands of Nosy Hao and Nosy Fasy. Continuing this work and drawing on recent experiments (cf for example the report on the *Octopus vulgaris* study on the north-west African coast IRD EDITIONS 2002) would be most valuable.

It is worth considering a permanent NTZ, which would act as a sanctuary and source for the surrounding area, and would allow the study of the distribution patterns of individuals over time .

The *Tridacna* sp. population around Nosy Hao must be protected.

A little-exploited source of animal protein in the area can be found in the bivalve population of the sedimentary lagoon, for example between Andavadoaka and Antseranambe Point. Its controlled use, with the careful conservation of a reproductive stock, could be of interest to the community of Andavadoaka.

In addition to octopus, certain other molluscs are exploited, such as certain cowries (*Cypraea annulus*) which serve to make cement for constructions, and certain species present a commercial interest (textile cone shells, some helmet shells). A Fasciolarid, *Pleuroploca trapezium* is often used as a decorative border to mark private property. A species of Mitridae *Mitra coffea* is sought after for its social importance (as jewellery).

It would be worth surveying these species in order to track any variations in population in order to evaluate the anthropogenic pressure exerted on them, and its consequences.

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PHYLUM: MOLLUSCA	Abundance	Trophic Guild
<b>Class: GASTROPODA</b>		
<b>Sub-Class: PROSOBRANCHIA (STREPTONEURA)</b>		
<b>Order: ARCHAEOGASTROPODA</b>		
<b>Super Family: PLEUROTOMARIACEA</b>		
<b>Family: Haliotidae</b>		1
<i>Haliotis ovina?</i> Gmelin, 1791		
<i>Haliotis varia</i> Linné, 1758	+	
<b>Super Family: PATELLACEA</b>		
<b>Family: Patellidae</b>		1
<i>cf Cellana radiata</i> Born, 1778 <i>subsp enneagona</i> Reeve, 1854	+	
<i>Patella barbara</i> Linné, 1758		
<i>Patella chapmani</i> Tenison-Woods, 1876	+	
<i>Patella flexuosa</i> Quoy et Gaimard, 1834		
<b>Family: Cocculinidae</b>		
<i>cf Cocculina</i> Dall, 1882	+	
<b>Super family: TROCHACEA</b>		
<b>Family: Trochidae</b>		1,9
<i>Clanculus flosculus</i> Fischer, 1878	+	
<i>Clanculus puniceus</i> Philippi, 1846	+	
<i>Tectus spl</i>	++	
<i>Tectus virgatus</i> Gmelin, 1791	+	
<i>Trochus cariniferus</i> Reeve, 1861	+	
<i>Trochus radiatus</i> Gmelin, 1791		
<i>Trochus virgatus</i> Gmelin, 1791	+	
<b>Family: Turbinidae</b>		1
<i>Lunella coronata</i> Gmelin, 1791	+	
<i>Turbo argyrostomus</i> Linné, 1758	++	
<i>Turbo chrysostomus</i> Linné, 1758	+	
<i>Turbo imperialis</i> Gmelin, 1791	+	
<i>Turbo japonicus</i> Reeve, 1848	+	
<i>Turbo marmoratus</i> Linné, 1758	+	
<b>Family: Phasianellidae</b>		
<i>Phasianella variegata</i> Lamarck, 1822	+	
<b>Super Family: NERITACEA</b>		
<b>Family: Neritidae</b>		1
<i>Nerita textilis</i> Gmelin, 1791	++	
<i>Nerita albicilla</i> Linné, 1758	+	

<i>Nerita plicata</i> Linné, 1758	+++	
<i>cf Nerita undata</i> Linné, 1758	+	
<b>Order: CAENOGASTROPODA</b> <b>(MESOGASTROPODA)</b>		
<b>Super Family: LITTORINACEA</b>		
<b>Family: Littorinidae</b>		
<i>Littorina scabra</i> Linné, 1758	++	
<b>Super Family: CERITHIACEA</b>		
<b>Family: Vermetidae</b>		9
<i>Siphonium sp</i>		
<i>Spirogyphus annulatus</i> Daudin, 1800		
<i>sp</i>	++	
<b>Family: Planaxidae</b>		1
<i>Planaxis sulcatus</i> Born, 1778	++	
<b>Family: Modulidae</b>		1
<i>Modulus tectum</i> Gmelin, 1791	+	
<b>Family: Potamididae</b>		
<i>Terebralia palustris</i> Linné, 1758	+++	
<b>Family: Cerithiidae</b>		1,9
<i>Cerithium alveolus</i> Honbron et Jacquinot, 1854	+	
<i>Cerithium caeruleum</i> Sowerby, 1855	+	
<i>Cerithium echinatum</i> Lamarck, 1822	++	
<i>Cerithium nodulosum</i> Bruguière, 1792	++	
<i>Clypeomorus concisus</i> Hombron et Jacquinot, 1854		
<i>Clypeomorus batillariaeformis</i> Habe et Kosuge, 1966	+++	
<i>Rhinoclavis aspera</i> Linné, 1758	+	
<i>Rhinoclavis articulata</i> Adams et Reeve, 1850	+	
<b>Super Family: STROMBACEA</b>		
<b>Family: Strombidae</b>		1
<i>Lambis chiragra arthritica</i> Röding, 1798	++	
<i>Lambis scorpius indomaris</i> Abbott, 1961	+	
<i>Lambis truncata</i> Humphrey, 1786	++	
<i>Strombus aurisdianae aurisdianae</i> Linné, 1758	+	
<i>Strombus decorus decorus</i> Röding, 1798	++	
<i>Strombus dentatus</i> Linné, 1758		
<i>Strombus gibberulus gibberulus</i> Linné, 1758	+	
<i>cf Strombus granulatus</i> Swainson, 1822	+	
<i>cf Strombus labiatus olydius</i> Duclos, 1844	+	
<i>Strombus lentiginosus</i> Linné, 1758	+	
<i>Strombus mutabilis</i> Swainson, 1821	+	
<i>Strombus ochroglottis</i> Abbott, 1960	+	
<b>Super Family: CALYPTRAEACEA</b>		
<b>Family: Calyptraeidae</b>		3
<i>Cheila equestris</i> Linné, 1758	+	
<i>Cheila tectumsinense</i> Lamarck, 1822		

**Super Family: TRIVIACEA****family: Triviidae**

15

*Trivirostra exigua* Gray, 1831

+

*Trivirostra oryza* Lamarck, 1811

+

**Super Family: CYPRAEACEA****family: Cypraeidae**

1,3

*Cypraea alisonae* Burgess, 1983

+

*Cypraea annulus* Linné, 1758

++++

*Cypraea arabica* Linné, 1758

+

*Cypraea argus* Linné, 1758

+

*Cypraea caputserpentis* Linné, 1758

+

*Cypraea carneola* Linné, 1758

+

*Cypraea caurica* Linné, 1758

+

*Cypraea chinensis* Gmelin, 1791

+

*Cypraea circercula* Linné, 1758

+

*Cypraea erosa* Linné, 1758

++

*Cypraea fimbriata* Gmelin, 1791

+

*Cypraea helveola* Linné, 1758

+

*Cypraea histrio* Gmelin, 1791

++

*Cypraea isabella* Linné, 1758

++

*Cypraea kieneri* Hidalgo, 1906

+

*Cypraea lynx* Linné, 1758

++

*Cypraea mappa* Linné, 1758

+

*Cypraea minoridens* Melvill, 1901

+

*Cypraea moneta* Linné, 1758

+

*Cypraea nucleus* Linné, 1758

+

*Cypraea owenii* Sowerby, 1837

+

*Cypraea poraria* Linné, 1758*Cypraea scurra* Gmelin, 1791

+

*Cypraea staphylaea* Linné, 1758

+

*Cypraea talpa* Linné, 1758

+

*Cypraea teres* Gmelin, 1791

+

*Cypraea tigris* Linné, 1758

+

*Cypraea vitellus* Linné, 1758

+

*Cypraea sp***Super Family: NATICEA****Family: Naticidae**

12

*Mamilla melanostoma* Gmelin, 1791

+

*Mamilla simiae* Deshayes, 1848

+

*cf Natica onca* Röding, 1798

+

*Polinices flemingianus* Recluz, 1844

+

*Polinices tumidus* Swainson, 1840

+

**Super Family: TONNACEA****Family: Cassidae**

14

*Casmaria erinaceus* Linné, 1758

+

*Casmaria ponderosa* Link, 1807

+

*Cassis cornuta* Linné, 1758

+

<i>Cypraeacassis rufa</i> Linné, 1758	+	
<b>Family: Tonnidae</b>		6,14
<i>Malea pomum</i> Linné, 1758	+	
<i>Tonna canaliculata</i> Linné, 1758	+	
<i>Tonna perdx</i> Linné, 1758	+	
<b>Family: Cymatidae</b>		14
<i>Charonia tritonis tritonis</i> Linné, 1758	+	
<i>cf Cymatium aquatile</i> Reeve, 1844	+	
<i>Cymatium hepaticum</i> Röding, 1798	+	
<i>Cymatium lotorium</i> Linné, 1758	+	
<i>Cymatium nicobaricum</i> Röding, 1798		
<i>Distorsio anus</i> Linné, 1758	+	
<b>Family: Bursidae</b>		11
<i>Bursa bubo</i> Linné, 1758		
<i>Bursa bufonia</i> Gmelin, 1791		

#### Order: (NEOGASTROPODA)

##### Super Family: MURICACEA

##### Family: Coralliophilidae 13

*Coralliophila neritoidea* Lamarck, 1816 +

*Rapa incurvus* Dunker, 1852 +

##### Family: Muricidae 10

*Chicoreus ramosus* Linné, 1758 ++

*Drupa lobata* Blainville, 1832

*Drupa ricina albolabris* Blainville, 1832 +

*Drupella cornus* Röding, 1798

*Mancinella tuberosa* Röding, 1798 +

*Morula granulata* Duclos, 1832 +

*Morula uva* Röding, 1798 +

*Naquetia triquetra* Born, 1778

*Nassa francolina* Bruguière, 1789

*Purpura persica* Linné, 1758

*Thais aculeata* Deshayes, 1844

##### Super Family: BUCCINACEA

##### Family: Buccinidae 9;10

*Engina mendicaria unilineata* Linné, 1758 +

*cf Phos cyanostoma* Adams, 1850 +

*Prodotia crocata* Reeve, 1846 +

##### Family: Columbelloidea

*Euplica turturina* Lamarck, 1822 +

*Mitrella albina* Kiener, 1841 +

*Pyrene flava* Bruguière, 1789 +

##### Family: Nassariidae 9;10

*Nassarius albescens* Dunker, 1846 +

*Nassarius albescens gemmuliferus* Adams, 1852 +

*Nassarius arcularius plicatus* Röding, 1798 ++

*Nassarius margariferus* Dunker, 1847

*Nassarius papillosus* Linné, 1758 +

##### Family: Fasciolaridae 10

<i>Latirus craticulatus</i> Gmelin, 1791	+	
<i>cf Latirus turritus</i> Gmelin, 1791	+	
<i>Peristernia forskali</i> Tapparone-Canefri, 1879	+	
<i>Pleuroploca filamentosa</i> Röding, 1798	++	
<i>Pleuroploca trapezium</i> Linné, 1758	+++	
<b>Family: Melongenidae</b>		
<i>Volema pyrum</i> Gmelin, 1791	+	
<b>Super Family: VOLUTACEA</b>		
<b>Family: Olividae</b>		9;10
<i>Oliva annulata</i> Gmelin, 1791	+	
<i>cf Oliva caerulea</i> Röding, 1798	+	
<i>Oliva olympiada</i> Duclos, 1844		
<i>Oliva sericea</i> Röding, 1798	+	
<i>Oliva tigrina</i> Lamarck, 1811	+++	
<b>Family: Vasiidae</b>		11,12
<i>Vasum ceramicum</i> Linné, 1758		
<i>Vasum turbinellus</i> Linné, 1758	+	
<b>Family: Mitridae</b>		9;10
<i>Mitra coffea</i> Schubert et Wagner, 1829	+	
<i>Mitra cucumerina</i> Lamarck, 1811	+	
<i>cf Mitra fraga</i> Quoy et Gaimard, 1833	+	
<i>Mitra imperialis</i> Röding, 1798	+	
<i>Mitra litterata</i> Lamarck, 1811		
<i>Mitra mitra</i> Linné, 1758		
<i>Mitra paupercula</i> Linné, 1758	+	
<i>cf Mitra rubritincta</i> Reeve, 1844	+	
<i>Mitra stictica</i> Linné, 1758		
<i>Mitra tabanula</i> Lamarck, 1811		
<i>Pterygia crenulata</i> Gmelin, 1791		
<i>Pterygia nucea</i> Gmelin, 1791		
<i>Scabricola bicolor</i> Swainson, 1824	+	
<b>Family: Costellariidae</b>		
<i>Vexillum intermedium</i> Kiener, 1838	+	
<i>cf Vexillum modestum</i> Reeve, 1845	+	
<i>Vexillum osiridis</i> Issel, 1869	+	
<i>cf Vexillum unifascialis</i> Lamarck, 1811	+	
<b>Family: Harpidae</b>		
<i>Harpa amouretta</i> Röding, 1758	+	
<i>Harpa major</i> Röding, 1798	+	
<b>Family: Cancellariidae</b>		
<i>Scalptia scalata</i> Sowerby, 1833	+	
<b>Super Family: CONACEA</b>		
<b>Family: Turridae</b>		10
<i>Lophiotoma cingulifera</i> Lamarck, 1822		
<b>Family: Conidae</b>		6,11,12
<i>cf Conus characteristicus</i> Fischer, 1807		
<i>Conus arenatus</i> Hwass, 1792	++	
<i>Conus augur</i> Lightfoot, 1786	+	
<i>Conus aulicus</i> Linné, 1758		

<i>Conus auricomus</i> Hwass, 1792	+
<i>Conus betulinus</i> Linné, 1758	
<i>Conus capitaneus</i> Linné, 1758	
<i>Conus catus</i> Hwass, 1792	+
<i>Conus chaldeus</i> Röding, 1798	+
<i>Conus circumclausus</i> Fenaux, 1942	+
<i>cf Conus colubrinus</i> Lamarck, 1810	+
<i>cf Conus convolutus</i> Sowerby, 1857	+
<i>Conus coronatus</i> Gmelin, 1791	
<i>Conus ebraus</i> Linné, 1758	++
<i>Conus episcopus</i> Hwass, 1792	
<i>Conus episcopus elongata</i> Hwass, 1792	
<i>Conus figulinus</i> Linné, 1758	+
<i>Conus fuscatus</i> Born, 1778	
<i>Conus geographus</i> Linné, 1758	+
<i>cf Conus generalis</i> Linné, 1767	+
<i>Conus glaucus</i> Linné, 1758	
<i>Conus gubernator</i> Hwass, 1792	+
<i>Conus leopardus</i> Röding, 1798	+
<i>Conus litteratus</i> Linné, 1758	+
<i>Conus lividus</i> Hwass, 1792	+
<i>Conus maldivus</i> Hwass, 1792	+
<i>Conus miles</i> Linné, 1758	++
<i>Conus miliaris</i> Hwass, 1792	+++
<i>Conus mitratus</i> Hwass, 1792	+
<i>Conus nanus</i> Broderip, 1833	
<i>Conus nussatella</i> Linné, 1758	
<i>Conus parvatus</i> Walls, 1979	+
<i>Conus quercinus</i> Lightfoot, 1786	+
<i>Conus rattus</i> Hwass, 1792	
<i>cf Conus sponsalis</i> Hwass, 1792	+
<i>Conus striatellus</i> Link, 1807	++
<i>Conus striatus</i> Linné, 1758	+
<i>Conus tenuistriatus</i> Sowerby, 1857	
<i>Conus terebra</i> Born, 1778	
<i>Conus tessulatus</i> Born, 1778	++
<i>Conus textile</i> Linné, 1758	++
<i>Conus tulipa</i> Linné, 1758	
<i>Conus verriculum</i> Reeve, 1843	+
<i>cf Conus vexillum</i> Gmelin, 1791	+
<i>Conus virgo</i> Linné, 1758	+
<b>Family: Terebridae</b>	
<i>cf Terebra affinis</i> Gray, 1834	+
<i>Terebra areolata</i> Link, 1758	
<i>Terebra crenulata interlineata</i> Deshayes, 1859	+
<i>cf Terebra dimidiata</i> Linné, 1758	+
<i>Terebra felina</i> Dillwyn, 1817	++
<i>Terebra maculata</i> Linné, 1758	+
<i>Terebra subulata</i> Linné, 1767	+
<i>Terenolla pygmea</i> Hinds, 1844	+

**Order: (HETEROGASTROPODA)**  
**Super Family: ARCHITECTONICACEA**  
**Family: Janthinidae**  
*Janthina balteata* Reeve, 1858

+

**Sub-Class: OPISTHOBRANCHIA**

**Sub-Order: BULLACEA**

**Family: Bullidae**  
*Bulla ampulla* Linné, 1758  
*Bulla vernicosa* Gould, 1854

++

**Order: ANASPIDEA**  
**Family: Aplysiidae**  
*cf Aplysia dactylomela* Rang, 1828  
*Dolabella auricularia* Lightfoot, 1786

+

+

**Order: NUDIBRANCHIA**  
**Family: Aegiretidae**  
*Notodoris minor* Eliot, 1904  
**Family: Chromodorididae**  
*Chromodoris africana* Eliot, 1904  
*Chromodoris elizabethina* Bergh, 1877  
*cf Chromodoris hamiltoni* Rudmann, 1977  
*Hypselodoris bullocki* Collingwood, 1881  
*cf Risbecia spl*  
**Family: Dorididae**  
*Halgerda toliara* Fahey et Gosliner, 1999  
*cf Platydorid cruenta*  
**Family: Phyllidiidae**  
*Phyllidiella meandrina* Pruvot-Fol 1957  
*cf Phyllidiella rosans* Bergh, 1873  
*Phyllidia varicosa* Lamarck, 1801

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**Ordre: SACOGLOSSA**  
**Family: Plakobranchidae**  
*cf Plakobranchus ocellatus* Van Hasselt, 1824

+

**Class: POLYPLACOPHORA**

**Order: (NEOLORICATA)**

**Family: Chitonidae**  
*Spl*

+

**Class: BIVALVIA**

**Sub-class: PTERIOMORPHA**

**Order: ARCOIDA**



**Family: Arcidae**

<i>Anadara antiquata</i> Linné, 1758	+++
<i>Arca avellana</i> Lamarck, 1819	+
<i>Barbatia revelata</i> Deshayes, 1863	+
<i>Barbatia tenella</i> Reeve, 1844	++

**Family: Glycymerididae**

<i>Tucetona audouini</i> Matsukama, 1985	+
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**Order MYTILOIDA****Super Family: MYTILACEA****Family: Mytilidae**

<i>Lithophaga teres</i> Philippi, 1846	
<i>Lithophaga</i> sp	+
<i>Modiolus auriculata</i> Krauss, 1848	++
<i>Modiolus</i> sp	
<i>Septifer bilocularis</i> Linné, 1758	+
cf <i>Septifer excisus</i> Wiegmann, 1837	+
Sp1	+

**Super Family: PINNACEA****Family: Pinnidae**

<i>Atrina vexillum</i> Born, 1778	++
cf <i>Pinna bicolor</i> Gmelin, 1791	++
<i>Pinna muricata</i> Linné, 1758	++

**Order PTERIOIDA****Super Family: PTERIACEA****Family: Pteriidae**

<i>Pinctada margaritifera</i> Linné, 1758	+
<i>Pteria aegyptiaca</i> Dillwyn, 1817	+
<i>Pteria penguin lotorium</i> Lamarck, 1819	
<i>Pteria tortirostris</i> Dunker, 1848	+

**Family: Isognomonidae**

<i>Isognomon isognomon</i> Linné, 1758	
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**Super Family: PECTINACEA****Family: Pectinidae**

<i>Chlamys lemniscata</i> Reeve, 1853	+
<i>Excellchlamys spectabilis</i> Reeve, 1853	+
<i>Gloripallium pallium</i> Linné, 1758	+

**Sub-order: OSTREINA****Super Family: OSTREACEA****Family: Ostreidae**

<i>Lopha cristagalli</i> Linné, 1758	+
<i>Pycnodonta hyotis</i> Linné, 1758	

<i>Saccostrea cucullata</i> Born, 1778	++
<i>Saccostrea</i> sp	
<b>Family: Spondylidae</b>	
<i>Spondylus</i> sp	+
<b>Super Family: LIMACEA</b>	
<b>Family: Limidae</b>	
<i>Ctenoides annulata</i> Lamarck, 1819	+
<i>Lima bullifera</i> Deshayes, 1863	
<b>Sub-class: HETERODONTA</b>	
<b>Order: VENEROIDA</b>	
<b>Super Family: ARCTICACEA</b>	
<b>Family: Trapeziidae</b>	
<i>Trapezium bicarinatum</i> Schumacher, 1817	+
<b>Super Family: LUCINACEA</b>	
<b>Family: Lucinidae</b>	
<i>Anodontia edentula</i> Linné, 1758	
<i>Codakia miniata</i> Deshayes, 1863	+
<i>Codakia punctata</i> Linné, 1758	++
<i>Codakia tigerina</i> Linné, 1758	++
<i>Divaricella daliana</i> Vanatta, 1901	
<b>Super Family: CARDITACEA</b>	
<b>Family: Carditidae</b>	
<i>Cardita variegata</i> Bruguière, 1792	+
<b>Super Family: CARDIACEA</b>	
<b>Family: Cardiidae</b>	
<i>Acrosterigma mauritanium</i> Deshayes, 1863	+
<i>Fragum fragum</i> Linné, 1758	
<i>Trachycardium elongatum</i> Bruguière, 1789	+
<i>Trachycardium flavum</i> Linné, 1758	++
<i>Trachycardium nebulosum</i> Reeve, 1845	+
<b>Super Family: GALEOMMATOIDEA</b>	
sp 1	+
<b>Super Family: TRIDACNACEA</b>	
<b>Family: Tridacnidae</b>	
<i>Tridacna maxima</i> Röding, 1798	++
<i>Tridacna squamosa</i> Lamarck, 1819	+
<b>Super Family: SOLENACEA</b>	
<b>Family: Solenidae</b>	
sp 1	+
<b>Super Family: TELLINACEA</b>	

**Family: Tellinidae**

*Quidnipagus palatam* Iredale, 1929  
*Scutarcopagia scobinata* Linné, 1758  
*Tellina crucigera* Lamarck, 1818  
*cf Tellina sulcata* Wood, 1815  
*Tellina virgata* Linné, 1758  
*Tellina sp1*

+

+

+

+

+

**Family: Donacidae**

*Donax faba* Gmelin, 1791

++

**Family: Psammobiidae**

*Asaphis violascens* Förskal, 1775

**Super Family: VENERACEA****Family: Veneridae**

*Gafrarium pectinatum* Linné, 1758  
*Lioconcha castrensis* Linné, 1758  
*Lioconcha ornata* Lamarck, 1817  
*Lioconcha tigrina* Lamarck, 1818  
*Periglypta crispata* Deshayes, 1853  
*Pitar affinis* Gmelin, 1791  
*Sp1*

++

+

+

++

+

+

**Class: CEPHALOPODA****Sub-Class: TETRABRANCHIATA****Family: Nautilidae**

*Nautilus sp*

6

**Sub-Class: DIBRANCHIATA****Ordre: TEUTHOIDEA****Family: Loliginidae**

*cf Loligo sp*  
*cf Sepiotheutis sp*

+

6

**Order: SEPIOIDEA****Family: Spirulidae**

*Spirula spirula* Linné, 1758

**Family: Sepiidae**

*cf Sepia australis* Linné, 1758  
*cf Sepia papillata* Quoy et Gaimard, 1832

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+

6

**Order: OCTOPODA**

**Super Family: OCTOPODOIDEA****Family: Octopodidae***Octopus cyanea* Gray, 1849

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6,12

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238

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**Trophic guild code**

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1: herbivore (algae-grazer)

3: invertebrate sessile grazer

6: microcarnivore;piscivore

9: detritivore, saprophyte

10: microcarnivore

11: carnivore;wormivore

12: carnivore;malacophages

13: microcarnivore;alcyonians or madrepores

14: carnivore;echinoderms

15: filter-feeder

16: parasite

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## APPENDIX 4.

### Details of variables collected during monitoring surveys for Reef Fish, Macro-Invertebrates and Benthic Cover

#### 4.1 Reef Fish

Reef Fish Families	Main Trophic Guilds	Size Classes (cm) recorded for each family
Serranidae	Piscivore/Invertivore	0-5
Lutjanidae	Piscivore/Invertivore	5-10
Lethrinidae	Piscivore/Invertivore	10-15
Haemulidae	Invertivore	15-20
Mullidae	Invertivore	20-25
Balistidae	Invertivore	25-30
Chaetodontidae	Corallivore/Omnivore	30-35
Scaridae	Herbivore	35-40
Acanthuridae	Herbivore	40-45
Siganidae	Herbivore	45-50
Pomacentridae	Herbivore/Planktivore	50-60
Caesionidae	Planktivore	60-70
Labridae	Carnivore/Omnivore	70-80
Pomacanthidae	Carnivore/Omnivore	80-90
Scombridae	Piscivore	90-100
Carangidae	Piscivore	

#### 4.2 Macro-Invertebrates

Phyla	Category	Genus	Phyla	Category	Genus
Echinoderms	Urchins	Diadema	Echinoderms	Sea Cucumbers (Holothurians)	Stichopus
		Echinothrix			Pearsonothuria
		Toxopneustes	Crustaceans	Lobsters	Other
		Tripneustes			
		Echinometra		Mantis Shrimps	Any
		Heterocentrotus			Any
		Other	Molluscs	Bivalves	Tridacna
	Sea-stars	Acanthaster			Hipoglossus
		Linkia			Pinctada
		Culcita			Lopha
		Nardoa			Atrina
		Other			Spondilus
	Sea Cucumbers (Holothurians)	Actinopyga		Gastropods	Lambis
		Bohadschia			Cypraea
		Holothuria			Cassia
		Thelonata	Charonia		
			Cepahlopods	Octopus	

## Benthic Categories

Category	HC Lifeform	Code (English)	Code (French)*
Sand		SD	SA
Silt		SI	BO
Rock		RC	RO
Rubble		RB	DEB
Dead Coral		DC	CX
Hard Coral		HC	CV
Acropora:	Branching	ACB	
	Digitate	ACD	
	Submassive	ACS	
	Tabulate	ACT	
	Encrusting	ACE	
Non-Acropora:	Branching	CB	
	Encrusting	CE	
	Foliose	CF	
	Massive	CM	
	Submassive	CS	
	Mushroom	CMU	CL
Soft Coral		SC	CMO
Sponge		SP	EP
Zooanthid		ZO	
Ascidian		AS	
Anemone		AN	
Giant Clam		GC	BE
Other Invertebrate		OT	
Halimeda		HA	
Calcified Algae		CA	AC
Macroalgae		MA	AD / AG
Turf Algae / Algal Assemblage		TA / AA	
Blue-Green Algae		BGA	CYA
Seagrass		SG	HE

\* where different from the code in English

## APPENDIX 5

### Environmental Parameters for coral reef sites surveyed.

Date	Dive #	Time	Location	Depth (m)	SST (°C)	Sea State	Wind Direction	Cloud Cover
26/11/06	1	10:53	Shark Alley	10-12	28	2	NW	2
27/11/06	2	09:57	Nosy Fasy	8-10	28	3	NW	2
"	3	15:08	"	10-12	28	3	NW	3
28/11/06	4	09:51	Andravamaike	20-22	28	3	SW	3
"	5	13:18	Shark Alley	8-10	28	4	SW	4
29/11/06	6	08:24	'THB'	10-12	28	3	SW	2
"	7	11:38	"	10-14	28.5	3	SW	2
30/11/06	8	09:08	Valleys	6-10	28	3	N	2
"	9	12:23	"	7-10	28	3-4	N	2
02/12/06	10	09:24	Coco Beach	5-8	28	3	SW	3
"	11	12:19	"	6-9	28	3	SW	3
03/12/06	12	09:17	Andavadoaka Rock	5-8	28.5	2	SW	2
"	13	11:54	"	"	28.5	2	SW	2
04/12/06	14	09:25	'007'	8-10	28	4	SW	2
"	15	11:19	"	"	28	4	SW	2
05/12/06	16	08:37	Recruitment	11-13	28	3	N	4
"	17	10:50	"	"	28	4	N	3
06/12/06	18	08:10	Half Moon	6-10	28	3	N	4
"	19	10:42	"	"	28.5	4	N	4

## APPENDIX 6.

### Benthic Composition at 10 coral reef sites in the Andavadoaka region. (Mean Percentage Cover)

Benthic Category	Shark Alley	Nosy Fasy	Valleys	THB	007	Recruitment	Coco Beach	Andavadoaka Rock	Half Moon	Andravamaiké
N =	8	8	8	8	6	6	8	8	8	4
Sand	2.5	4	2.5	0.25	0	0.33	0	6.5	1.25	14
Silt	0	0	0	0	0	0	0.5	4.5	0.5	0
Rock	4	2	1.5	0.5	0.67	0.33	2.5	0.75	0.25	6
Rubble	2.25	3.5	4.25	0.5	1	0.67	0	7.75	6.25	3
Dead Coral	0	0.25	0	0	0	0	0	0	0	0
<b>Abiotic</b>	<b>8.75</b>	<b>9.75</b>	<b>8.25</b>	<b>1.25</b>	<b>1.67</b>	<b>1.33</b>	<b>3</b>	<b>19.5</b>	<b>8.25</b>	<b>23</b>
ACB	0	0	0.25	0.5	1.67	1.67	0	0	0	0
ACD	0	0	0	1.75	0.33	0	0	0	0	0.5
ACS	0	0	0.5	1.5	3.67	4.33	0	0	0.25	0
ACT	0	0	0	5	0.33	4.67	0	0	0	1.5
ACE	0.25	0.75	0.5	0.5	0	0	0	0	0	1
<b>Acropora</b>	<b>0.25</b>	<b>0.75</b>	<b>1.25</b>	<b>9.25</b>	<b>6</b>	<b>10.67</b>	<b>0</b>	<b>0</b>	<b>0.25</b>	<b>3</b>
CB	0	0	0	5.25	3.33	0.67	0	0	0.25	0
CE	7.75	5	3.25	17.25	12	28.67	4.5	2.75	0.75	6.5
CF	0	0	0	0.25	21.67	1	0	0	0	0
CM	10.75	7	5.75	4	0	1.33	0	3.25	2.25	6
CS	3.25	4.5	3.5	4.25	6.67	3.67	27.5	2	0.5	0.5
CMU	0.5	0	0	0	0	0	0.25	0.75	0	0
<b>Non-Acropora</b>	<b>22.25</b>	<b>16.5</b>	<b>12.5</b>	<b>31</b>	<b>43.67</b>	<b>35.33</b>	<b>32.25</b>	<b>8.75</b>	<b>3.75</b>	<b>13</b>
<b>Hard Coral</b>	<b>22.5</b>	<b>17.25</b>	<b>13.75</b>	<b>40.25</b>	<b>49.67</b>	<b>46</b>	<b>32.25</b>	<b>8.75</b>	<b>4.</b>	<b>16</b>
<b>Soft Coral</b>	<b>9</b>	<b>6.5</b>	<b>0.5</b>	<b>10.25</b>	<b>4.33</b>	<b>5.67</b>	<b>2.25</b>	<b>4.75</b>	<b>10.5</b>	<b>20.5</b>
Sponges	0.25	0.75	1.75	0.75	1.33	1	0.25	1.25	1.5	7
Zooanthids	0	0	0	1.75	0.67	0.67	0	0.25	0	0
Anemones	0	0	0	0.75	1.33	0	0	0	0	0
Other Invertebrates	0.75	0.75	0	0.5	0	0.33	0	0.5	0.25	0.5
<b>Invertebrates</b>	<b>1</b>	<b>1.5</b>	<b>1.75</b>	<b>3.75</b>	<b>3.33</b>	<b>2</b>	<b>0.25</b>	<b>2</b>	<b>1.75</b>	<b>7.5</b>
Halimeda	0	0	0.25	0	0	0	0.25	0	0	0
Calcified Algae	18	27.5	27.25	17.25	10.67	15	11.25	8.5	12.75	16
<b>All Calcified</b>										
<b>Algae</b>	<b>18</b>	<b>27.5</b>	<b>27.5</b>	<b>17.25</b>	<b>10.67</b>	<b>15</b>	<b>11.5</b>	<b>8.5</b>	<b>12.75</b>	<b>16</b>
Macroalgae	7.25	7	8.25	2.5	4.33	5.67	7.25	5.5	8.75	0
Turf Algae / AA	33.5	30.5	40	24.75	25.67	24.33	44	50.5	49.75	17
Blue-green Algae	0	0	0	0	0.33	0	0	0.5	4.25	0
<b>Non Calcified</b>										
<b>Algae</b>	<b>40.75</b>	<b>37.5</b>	<b>48.25</b>	<b>27.25</b>	<b>30</b>	<b>30</b>	<b>50.75</b>	<b>56</b>	<b>58.5</b>	<b>17</b>
<b>All Algae</b>	<b>58.75</b>	<b>65</b>	<b>75.5</b>	<b>44.5</b>	<b>40.67</b>	<b>45</b>	<b>62.5</b>	<b>64.5</b>	<b>75</b>	<b>33</b>



## APPENDIX 7.

### Mean Percent Cover of Hard Coral Genera at 10 Andavadoaka coral reef sites.

Benthic Category	Shark Alley	Nosy Fasy	Valleys	THB	007	Recruitment	Coco Beach	Andavadoaka Rock	Half Moon	Andravamaike
N =	8	8	8	8	6	6	8	8	8	4
Acanthastrea	0.25	0.25	0.25	0	0	0	0	0	0	0
Acropora	0.25	0.75	1.25	9.25	6.33	10.67	0	0	0.25	3
Cyphastrea	0.25	0.25	0	0	0	0	0	0	0	0
Echinopora	0.25	0.5	0.25	8.5	4.67	15.33	0	0	0	2.5
Favia	2.5	1	1.75	1.5	0	0	0	1.5	0.75	0
Favites	0.5	1.5	0.75	0	0	0.33	0.25	0	0.25	0
Fungia	0.25	0	0	0	0	0	0.25	0.25	0	0
Galaxea	0	0	0.5	0.5	0.33	0.33	0.75	0.25	1	0
Goniastrea	0.25	0	0.25	0.75	0	0.33	0	0	0	0
Herpolitha	0	0	0	0	0	0	0	0.5	0	0
Hydnophora	0	0.5	0.25	0.25	0	0	0	0.25	0	0
Leptastrea	0.25	0	0	0	0	0	0	0	0	0
Lobophyllia	0.25	0	0	0.25	0	0	0	0	0	0
Millepora	0.75	0.25	0	0	0	0.67	0	0	0	4
Montipora	0.25	0	0	1.75	23.33	3.67	0	0	0	0
Mycodinium	0	0	0	0.25	0	0	0	0.25	0	0
Oxyphora	0	0	0	0	0	1	0	0	0	0
Pachyseris	0	0	0	0	0	0.33	0	0	0.25	0
Pavona	0	0	0.5	2.5	1.33	1.33	27.25	0	0	0
Platygyra	1	0.25	0.5	0.75	0	0.33	0	0.5	0.25	1
Pocillopora	2.75	4.75	3.5	0.75	4	1.33	0.25	2.25	0.25	0.5
Porites branching	0	0	0	4	3.33	0	0	0	0	0
Porites massive	8.25	5.25	3.25	2.25	0	1.33	0	1.75	0.75	4
Porites	1.25	0.25	0.25	2	2.67	3	0.25	1	0	0
Psammacora	0	0	0	0	0	0	0.25	0	0	0
Seriatopora	0	0	0	1	0	0.33	0	0	0.25	0
Stylophora	0	0	0	0.5	0	0.33	0.25	0	0	0
Turbinaria	0.25	0.25	0	0.5	3	1.67	0.25	0	0	0

## APPENDIX 8.

### Reef Fish biomass for 14 fish families at nine sites and three reef types at Andavadoaka.

(Mean Values and Standard Error)

#### 8.a Mean Values

Family /	Site:	Nosy Fasy	Shark Alley	Valleys	THB	Recruitment	007	Coco Beach	Andava' Rock	Half Moon	Barrier	Patch	Fringing
	N:	3	3	3	2	3	2	3	3	2	9	7	8
Acanthuridae		248.83	137.81	159.38	212.22	132.94	166.54	29.79	109.82	0.70	182.01	176.51	52.53
Balistidae		23.88	2.75	2.44	5.50	5.48	14.78	0.00	8.53	0.00	9.69	8.14	3.20
Caesionidae		0.00	14.26	184.53	53.91	0.00	20.22	205.48	68.74	0.00	66.26	28.88	102.83
Chaetodontidae		6.56	6.52	1.96	5.30	23.70	8.62	6.44	11.90	0.00	5.01	11.51	6.88
Haemulidae		0.00	1.73	0.00	0.00	33.62	12.17	30.53	8.11	0.00	0.58	13.08	14.49
Labridae		47.71	47.18	22.93	32.11	34.04	21.03	51.65	77.78	17.17	39.28	29.50	52.83
Lethrinidae		0.00	6.24	0.00	244.31	9.82	0.00	0.82	0.00	0.00	2.08	107.51	0.31
Lutjanidae		0.00	13.19	1.47	56.41	218.71	7.40	81.12	0.00	1.10	4.88	88.78	30.69
Mullidae		28.35	3.12	1.32	9.33	1.97	0.00	0.12	1.32	1.97	10.93	4.56	1.03
Pomacanthidae		36.94	0.00	2.17	6.40	9.96	13.04	1.35	1.23	0.18	13.04	9.32	1.01
Pomacentridae		11.15	10.02	8.88	10.59	11.79	33.83	43.62	26.97	31.28	10.01	17.57	34.29
Scaridae		0.00	31.24	39.46	20.61	23.69	40.17	12.85	47.89	0.13	23.57	27.08	22.81
Serranidae		0.00	26.58	0.00	1.25	8.10	13.71	0.00	33.76	0.00	8.86	6.76	12.66
Siganidae		0.00	2.32	1.16	2.32	0.00	0.00	0.00	0.00	0.00	1.16	1.00	0.00
<b>Total</b>		<b>403.42</b>	<b>302.95</b>	<b>425.68</b>	<b>660.27</b>	<b>513.83</b>	<b>351.50</b>	<b>463.77</b>	<b>396.06</b>	<b>52.53</b>	<b>377.35</b>	<b>530.21</b>	<b>335.57</b>

## 8.b

## Standard Error

Family /	Site:	Nosy Fasy	Shark Alley	Valleys	THB	Recruitment	007	Coco Beach	Andava' Rock	Half Moon	Barrier	Patch	Fringing
	N:	3	3	3	2	2	3	3	3	2	9	7	8
Acanthuridae		109.35	57.10	22.31	95.59	2.33	43.64	28.91	47.63	0.99	36.15	35.85	24.41
Balistidae		3.52	1.69	1.49	6.73	2.58	4.95	0.00	2.98	0.00	3.91	3.05	1.87
Caesionidae		0.00	11.16	88.46	66.03	0.00	0.00	146.48	59.08	0.00	38.54	24.23	56.43
Chaetodontidae		1.15	7.24	1.05	4.40	25.57	5.79	5.72	9.70	0.00	2.02	5.76	3.72
Haemulidae		0.00	2.12	0.00	0.00	47.55	17.21	24.08	9.93	0.00	0.61	10.43	9.07
Labridae		0.34	8.01	4.12	8.45	10.55	4.15	18.94	67.71	3.93	4.88	4.15	22.22
Lethrinidae		0.00	4.95	0.00	274.14	13.89	0.00	1.00	0.00	0.00	1.66	105.30	0.33
Lutjanidae		0.00	12.34	0.90	13.40	118.24	7.36	93.05	0.00	1.55	3.80	42.46	30.92
Mullidae		20.42	1.73	1.61	1.54	2.79	0.00	0.15	1.61	2.79	6.92	1.98	0.68
Pomacanthidae		15.89	0.00	1.56	7.84	13.59	11.22	1.65	1.51	0.25	7.50	4.12	0.67
Pomacentridae		1.20	2.76	2.29	1.63	7.53	28.75	12.98	9.30	3.07	1.01	6.74	5.48
Scaridae		0.00	11.06	12.07	12.13	10.40	34.07	15.09	31.89	0.19	7.57	8.08	12.93
Serranidae		0.00	12.72	0.00	1.53	11.45	8.81	0.00	31.95	0.00	5.67	3.37	11.27
Siganidae		0.00	2.85	1.42	2.85	0.00	0.00	0.00	0.00	0.00	0.87	1.08	0.00
<b>Total</b>		<b>104.91</b>	<b>64.89</b>	<b>76.05</b>	<b>446.17</b>	<b>70.95</b>	<b>144.47</b>	<b>288.78</b>	<b>242.16</b>	<b>3.14</b>	<b>41.39</b>	<b>161.36</b>	<b>126.87</b>

## APPENDIX 9.

### Mean densities of selected macro-invertebrates for nine sites at Andavadoaka.

(No. of individuals / hectare)

Invertebrate Category	Nosy Fasy	Shark Alley	Valleys	THB	Recruitment	007	Coco Beach	Andavadoaka Rock	Half Moon
N:	3	3	3	2	2	3	3	3	2
<i>Diadema</i>	0	0	93.33	173.33	0	1600.00	0	0	1160.00
<i>Echinothrix</i>	0	0	0	0	0	100.00	0	640.00	1600.00
<i>Echinometra</i>	0	0	906.67	266.67	0	0	0	40.00	0
<i>Acanthaster planci</i>	0	0	0	0	0	0	0	0	0
<i>Linkia</i>	120.00	0.00	80.00	0.00	20.00	220.00	306.67	893.33	100.00
<i>Culcita</i>	0	0	0	0	0	0	0	0	20.00
<i>Nardoa</i>	13.33	0	0	13.33	0	0	0	0	20.00
<i>Choriaster</i>	0	0	0	0	0	0	0	13.33	0
<i>Protoreaster</i>	0	0	0	0	0	20.00	0	13.33	0
Total Asteroidea	133.33	0	80.00	13.33	20.00	240.00	306.67	920.00	140.00
<i>Pearsonothuria graeffei</i>	40.00	13.33	13.33	66.67	80.00	80.00	53.33	13.33	0
<i>Holothuria atra</i>	40.00	13.33	0	0	0	0	0	0	0
Other Holothurians	0	0	13.33	13.33	0	0	0	13.33	0
Total Holothurians	80.00	26.67	26.67	66.67	80.00	80.00	53.33	26.67	0
Lobster	0	0	0	0	0	0	0	0	0
Anemone	0	0	0	1506.67	0	0	0	40.00	40.00
<i>Tridacna</i>	93.33	40.00	26.67	26.67	0.00	0.00	13.33	53.33	0
<i>Octopus</i>	13.33	0	0	0	0	0	0	0	0
<i>Charonia tritonis</i>	0	0	0	0	0	0	0	0	0
<i>Cassis cornuta</i>	0	0	0	0	0	0	0	0	0
<i>Lambis</i>	26.67	13.33	0	13.33	0	0	0	26.67	0
<i>Cypræidae</i>	120.00	13.33	53.33	26.67	0	0	13.33	0	0